



THE MAINE
AGRICULTURAL EXPERIMENT STATION
ORONO



Nitrogen from a clover crop alone is not sufficient to produce maximum yields of potatoes. The plot in the foreground received 120 pounds per acre of nitrogen in the fertilizer. The plot in the background received no nitrogen in the fertilizer. A good clover crop was plowed under on both plots the previous fall. The difference in yield was 32 barrels per acre in favor of additional nitrogen in the fertilizer.

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POTATOES

The potato industry is the most important agricultural enterprise in the State from the standpoint of cash income. The problems of this industry, therefore, naturally receive considerable attention in the research program of the Station. Furthermore, the potato growers themselves, becoming concerned with the disease problems threatening the success of their industry, have made available from the Potato Tax revenue, a substantial fund annually for research on methods for the control of the most serious potato diseases. The support for studies with potatoes, for the fiscal year ending June 30, 1942, was about equally divided between Potato Tax funds and those received from regular Federal and State appropriations. In addition, funds for the construction of a greenhouse at Aroostook Farm were made available from a carry-over of Potato Tax income from the 1940 potato crop. This new greenhouse was completed about January 1, 1942, and is a decided asset in the research program on potato diseases. There are, of course, problems in the production and marketing of potatoes aside from those of disease and these are receiving due attention as may be seen from this report.

POTATO DISEASES

The attention of everyone connected with the potato industry has been focused more recently upon leafroll (net necrosis), stem-end browning, bacterial ring rot, and purple top. Concentration of effort has been on these important disease problems but other diseases such as late blight, rhizoctonia, and mild mosaic have not been neglected.

Bacterial Ring Rot. There are three methods of approach for the control of ring rot in potatoes. The first and most promising method, on the long-time basis, is the development of a variety, or varieties, resistant or immune to the disease. The second method is applicable to present commercial varieties but only to those seed stocks which are known to be absolutely free of ring rot. It is a method of rigid sanitation. A third method is available to those growers who have seed stocks in which there is known to be ring rot infection. The method involves the purchase of a small quantity of new seed stock known to be free from infection with this disease,



FIG. 1. Green Mountain potato plant on the right showing typical bacterial ring rot symptoms in the field. Note healthy stalk on the left.

and the use of seed plot methods combined with rigid sanitation while increasing this stock for general farm planting. The evidence from research amply supports the statements just made as may be seen from the following discussion.

RESISTANT VARIETIES. A few named varieties of potatoes and several unnamed seedlings¹ have been found by Reiner Bonde and Stanislas F. Snieszko to be resistant or immune to ring rot infection. None of these in themselves offer much from the standpoint of a table stock potato. They do, however, provide parent material for hybridization with other varieties. They provide, also, assurance that in due time a good table stock potato can be developed which will be resistant or immune to ring rot. The production of new varieties requires several years, since all promising seedlings must be subjected to severe tests for resistance, and these tests are

¹ The potato breeding program is a cooperative study with the Bureau of Plant Industry of the U. S. Department of Agriculture. The headquarters of the Bureau staff in Maine is at Aroostook Farm, Presque Isle. Doctor H. A. Jones and Doctor F. J. Stevenson of the Bureau have rendered the potato growers inestimable service in this cooperative project. All of the new seedlings tested for disease resistance originate in this program.

laborious and time-consuming. Symptoms of this disease show only in mature or nearly mature plants or tubers. It happens frequently that susceptible plants do not contract the disease in a particular season. In order to make sure of resistance, therefore, a variety must be tested for two or more years.

DISEASE-FREE SEED STOCKS. The only hope for the immediate future, so far as the control of ring rot is concerned, is in the maintenance of seed stocks of our present varieties free from the disease. Stocks which are now known to be free from it should be guarded carefully through rigid methods of sanitation. Containers used to haul potatoes off the farm should be disinfected thoroughly before they are used for transporting seed stocks. Visitors to the farm during the growing season should not be permitted in the fields intended for seed stock production if by any chance they have visited other potato fields. The Experiment



FIG. 2. Spaulding Rose potato plants showing typical bacterial ring rot symptoms in the field. The plant on the left is slightly affected as evidenced by some chlorosis in the upper leaves and a slight wilting in some of the leaves. The one on the right has an advanced stage of the disease.

Station has laboratory facilities for expert diagnosis of ring rot in tubers suspected of this disease. Samples may be sent either to Aroostook Farm, Presque Isle, or to the Experiment Station, Orono, and will be checked free of charge. Approximately 150 samples were received last season, mostly from farmers in Aroostook County. The ultraviolet lamp was employed by Reiner Bonde and A. Frank Ross this year in order to test its effectiveness as an aid in eliminating affected tubers from seed stocks. A high percentage of the infected tubers can be removed by examining cut surfaces under the rays of the ultraviolet lamp. It was found, however, that 0.2 to 0.6 per cent of the affected tubers escaped detection by this method while 2.0 per cent escaped detection without the use of the lamp. The 0.2 per cent, however, is just that much too much to leave in any potatoes intended for planting. In case it is necessary for a grower to use stock which is known to have ring rot, he could remove a high proportion of the infected tubers with the use of an ultraviolet lamp if one were available. The removal of most of the infected tubers will be a help but will not be a cure.

SEED PLOTS. A seed plot method has been devised by Reiner Bonde which, so far as the test has gone, shows considerable promise for growers who wish to start with new seed stock and who are unable to purchase for their entire planting. Ring-rot-free seed stock should be obtained sufficient to plant about one-hundredth of the total farm potato acreage. This stock should be planted first and all containers and equipment for hauling, cutting and planting should be carefully disinfected before they are used for this stock. A plot should be selected on which potatoes were not planted the previous year. In all field operations on this plot, the equipment should be disinfected before it is taken into the plot. The grower himself should not go into the plot after having recently gone through his other fields. The plot should be rogued to remove leafroll and other diseases for which roguing is helpful. The roguing operation can be more effective if the plot is tuber-unit planted. One-tenth of the seed plot should be early-harvested to provide stock for planting the same size of plot the next year. The potatoes from the balance of the area should be harvested and stored in disinfected bins. It is desirable to store this seed in barrels which can be covered during the storage period. This stock

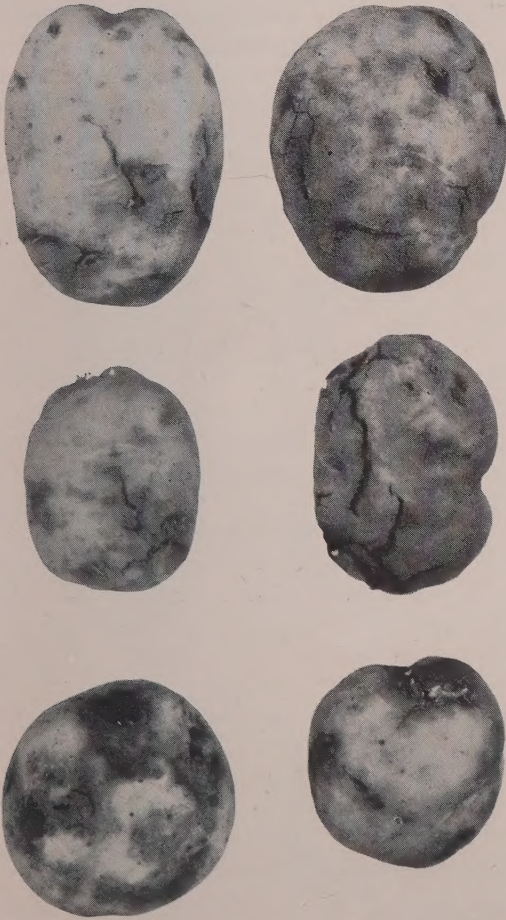


FIG. 3. Tubers showing external symptoms of bacterial ring rot. The four upper tubers show typical cracking in the Green Mountain variety. The two lower tubers show darkened discolorations beneath the periderm in the Irish Cobbler variety.

will be for an increase plot the second year which should be an acreage about one-tenth that of the total potato acreage. The third year of this program should see the entire farm planted to ring-rot-free seed stock. Should this method prove effective the ring rot disease could be eliminated entirely from the State within three years provided every grower adopted the plan and followed it conscientiously.

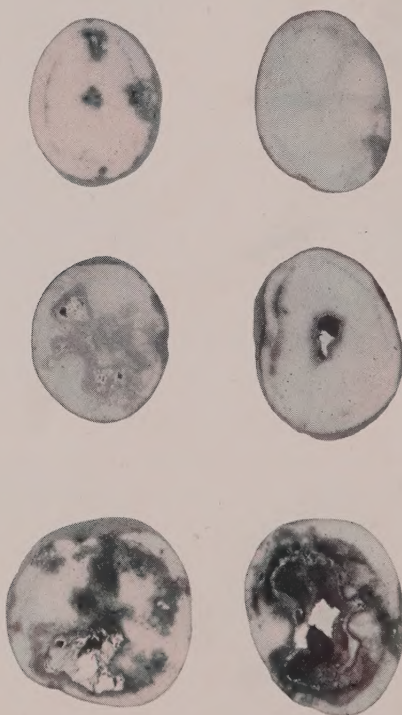


FIG. 4. Cut tubers showing different stages of vascular discoloration and decay caused by bacterial ring rot.

RING ROT IN SOIL. The ring rot organism apparently will not overwinter in the soil. It was found, however, by Reiner Bonde that it would carry over the winter in infected tubers which

developed volunteer plants. Diseased Katahdin potatoes were planted in 1940 during the harvest season. The tubers were put in trenches about six inches deep and covered so that the surface was fairly level. Part of each lot was covered further with a shallow layer of weeds and potato tops. Plants from the diseased tubers did not emerge until the first week in August, 1941, and growth of the plants was much retarded. Of the diseased tubers planted, 65 to 82 per cent survived and produced plants, and 42 to 57 per cent of the tubers planted produced plants with ring rot. (See Table 1 in the Appendix.) Volunteer potato plants were found in several commercial fields. In two fields, ring rot infected plants were found which had come from diseased tubers left in the field during the previous harvest season. These data are the basis for the recommendation that seed stocks free from ring rot should be planted on land which was not planted to potatoes the previous year.

DISINFECTANTS. Numerous chemicals have been tested for their effectiveness in disinfecting cut seed, containers, machinery, and storage bins. The acid mercury dip solutions acidulated with either hydrochloric or acetic acid (1 part corrosive sublimate in 500 parts water and .2% acid) were the most effective of all materials tried. Copper sulphate (1 pound in 10 gallons of water) was very effective in killing the ring rot organism on potato bags. Bordeaux mixture was not as effective as copper sulphate even when the copper strength of the two was the same. Coal tar disinfectants with a phenol coefficient of 6 were only fairly effective when used at a dilution of 1 quart in 50 gallons of water. Formaldehyde (1-120), Semesan Bel (1 pound in 7.5 gallons of water), and a number of other chemicals were shown to possess some value in controlling ring rot. Chlorox, a trade product containing 5.25 per cent by weight of sodium hypochlorite, was not effective for seed-piece disinfection when used in a concentration of 1-10 for periods up to 30 minutes.

In the process of treating storage bins and equipment used for marketing potatoes, care should be taken to remove dirt from the surfaces to be treated before the disinfectant is applied. It takes more disinfectant to wet a lot of dirt than it does to wet a relatively clean surface. Mercurial disinfectants may cause corrosion of exposed iron parts of machinery, and the removal of the mercury by the iron weakens the disinfectant solution.

Leafroll (Net Necrosis). Leafroll is a virus disease and is spread, very largely at least, by aphids. There are two general approaches to the control of this potato disease. One approach is through the development of resistant varieties and the second is through the production of seed stocks which are free, or practically free, from the leafroll disease in present varieties. Absolute freedom from this disease may not be attainable with susceptible varieties except under ideal conditions. Maximum yields of potatoes in Maine are assured, however, if the leafroll content of seed stocks is kept below 10 per cent.

RESISTANT VARIETIES. Potato varieties resistant or immune to leafroll are a definite possibility. Several thousand new seedlings² have been tested by Donald Folsom for resistance to leafroll in plots at Highmoor Farm; 2200 of the new seedlings were planted for the first time in 1941. Of all the seedlings exposed to the test from 1938 through 1940 only 6 came through the 1938 and 1939 test with clean readings and only one of these 6 remained apparently healthy in 1941. There are, however, 19 other seedlings which survived the exposures of 1939 and 1940 and remained apparently healthy in 1941. These 20 seedlings, 1 with 3 years' exposure and 19 with 2 years', certainly have considerable resistance to leafroll and some of them, as judged from appearances, have both satisfactory vines and tubers. Preliminary, small-scale cooking tests of these 20 in comparison with Green Mountains and Chippewas showed some to have promise for table stock quality. The next question is, will they produce barrels of potatoes per acre?

GOOD SEED STOCKS. The development of seed stocks which are free from the leafroll disease in susceptible varieties is a tedious process and one requiring care and close attention to detail.

ISOLATED PLOTS. The Station operates an isolated seed plot of about eight acres in the town of Winterville. Small quantities of all the potato varieties most commonly grown in Maine are carried in this plot and some progress has been made in obtaining

² The Station cooperates with the Bureau of Plant Industry of the U. S. Department of Agriculture in its potato breeding program, a portion of which is carried in Aroostook County. The Bureau field headquarters in Maine are at Aroostook Farm, Presque Isle. Doctor Henry A. Jones and Doctor Fred J. Stevenson of the Bureau have rendered excellent service to Maine in this program in their recognition of the important disease problems and in modifying the potato breeding program to best serve these needs.



FIG. 5. Looking ahead between Chippewas (A) which became 90 per cent leafroll in one year at Highmoor Farm, and Seedling X247-24 (B) which is still free of leafroll after several years' exposure at Highmoor Farm.

seed stocks with very low leafroll infection. All new seedlings with promise are planted in this plot so that they can be increased under conditions as favorable as possible for the production of clean seed. The Florida readings for leafroll on Sebago, Houmas, and Katahdins from the Winterville plot of 1941 were .7, .5, and .3 per cent respectively. Greenhouse checks showed Chippewas had 2.0 per cent and Pontiacs had 1.5 per cent leafroll. The goal, of course, on these seed stocks is a zero reading for this disease. Potatoes raised in this isolated plot are offered for sale first to the growers of foundation seed.

FOUNDATION SEED PROGRAM. This program is sponsored by the Station and closely supervised by G. W. Simpson and W. F. Porter. It has had a reasonable success. The Foundation samples in 1939, the first year for Foundation samples, averaged 1.5 per cent leafroll in the Florida readings and in 1940, 3.7 per cent. In 1939, 11.4 per cent of the samples in this test were without leafroll and in 1940, 9.6 per cent. The average leafroll for the samples from this program in the 1941 test was .9 per cent and 12.5 per cent of the samples showed no leafroll. The average for all other

samples in the Florida readings was 4.3 per cent leafroll and only 1.4 per cent of the samples were without this disease. The average Foundation seed stock, therefore, has been consistently better than the average of other seed stocks represented in the Florida Test plots.

FLORIDA TEST. The certified seed program conducted by the State Department of Agriculture is an important item in the program for the production of good seed stocks in potatoes. In view of the serious spread of leafroll in the 1937 crop the Station in cooperation with the State Department, as an aid to the certified seed growers, undertook a Florida Test as a means of locating any reasonably good seed stocks that might be left in the State. This program was supervised by Reiner Bonde and Donald Folsom of the Station and E. L. Newdick of the State Department of Agriculture. There were 102 samples in this first test which was conducted in the vicinity of Hastings, Florida, during January and February in 1938. In later years the test has been conducted in the vicinity of Homestead. This program has become increasingly popular and 450 samples were entered in the 1941 test. The varieties entered were Bliss Triumph, Chippewa, Earlane No. 2, Green Mountain, Houma, Irish Cobbler, Katahdin, Pontiac, and Warba, and the samples taken represented slightly over 5,000 acres. The Green Mountain variety led the list with slightly over 2,000 acres represented. Slightly over 2,300 acres represented had 2 per cent or less leafroll and 3 per cent or less mosaic. The stock with a reading of 2 per cent or less is considered reasonably satisfactory at present for use in growing certified seed. The potatoes produced on the 2,300 acres represented by these samples would plant in the neighborhood of 25,000 acres. Samples with readings of over 2 per cent but with less than 10 per cent represented a little over 2,040 acres. (Data on varieties and acreage are given in Tables 2 and 3 in the Appendix.) If the seed stocks from the acreage showing 10 per cent or less of leafroll were all planted in Maine they would be sufficient to plant about 25 per cent of the potato acreage.

APHID CONTROL. Aphids carry the leafroll virus from diseased plants to healthy ones. If means could be found to eliminate the aphid as a carrier there would be, so far as is known, practically no spread of this virus disease. It is known that aphids are rather

closely restricted as to plants on which they feed. Since annual farm crops are not available during the winter as a means of carrying the aphids through, they must overwinter on wild plants or perennial farm crops. The elimination of such winter hosts if they can be found and destroyed would end the war on these particular aphids. It is known that the buckthorn (*Rhamnus* sp.) and the rose (*Rosa* sp.) are overwintering host plants for aphids which feed on potatoes, and search is being made for other plants which serve this purpose. It is possible that potato growers in some areas may improve their situation by a removal of all of these overwintering host plants within an area closely surrounding their potato fields.

Considerable information is being obtained by W. A. Shands³ and G. W. Simpson regarding the summer hosts and flight habits of the aphids which infest potato fields. There has been much controversy among the growers over whether or not the pea aphid will feed on potatoes. Altogether, 60 collections of insects were made in the 1941 season involving 4,822 aphids of which 1,281 were adults which could be exactly identified as to species. (Detailed data are given in Table 4 in the Appendix.) No adults of the aphid species which feed on potatoes were found on peas and no adults of the pea aphid were found on potatoes. The buckthorn aphid, the green peach aphid, and the potato aphid were the ones most numerous on potatoes. These three together with the pea aphid were all found on clover and, also, on young clover in fields from which peas had been harvested.

The hitherto unexplained increase in the number of winged aphids on potatoes, that has been observed in August, was traced to weed hosts. Among the numerous weeds found to be, or suspected of being, breeding hosts, wild rutabaga (locally "mustard") and wild radish (locally "kale") were found to be the most important during the summer of 1941. Plants growing in waste places and in potato fields where large leaves could develop were far more productive of winged aphids in August and September than were plants of the same species growing in grain fields. It was found that a single mature plant of the wild rutabaga or radish was able to mature sufficient aphids to provide one for each potato plant on one-seventeenth acre of potatoes. The weeds commonly known as "mustard" and "kale" are, therefore, a tremendous potential source for a build-up in the aphid infestation.

INSECTICIDE TRIALS. Methods for insecticidal control of the aphids infesting potatoes were continued during the summer of 1941 by T. E. Bronson³ and G. W. Simpson on five farms in the vicinity of Houlton. Two plots approximately one-half acre in extent were provided on each farm⁴ for each of five experimental treatments. These consisted of applications of the following mixtures⁵: (1) insoluble copper-derris spray with 2 quarts of soybean oil and a pint of a conditioning agent in each 100 gallons; (2) as in (1) except for the substitution of bordeaux mixture for the insoluble copper; (3) insoluble copper-derris-pyrophyllite dust containing 0.75 per cent of rotenone and 1 per cent of crude soybean oil; (4) as in (3) except for the substitution of monohydrated copper sulfate and hydrated lime for the insoluble copper; and (5) basic or tribasic copper sulfate on check plots for control of fungus diseases.

At three farms, tractor-powered sprayers were equipped with

³ The Division of Truck Crop and Garden Insect Investigations, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, is cooperating with the Maine Station in the aphid control program. W. A. Shands and T. E. Bronson are the representatives from the Bureau in this program. The assistance rendered by these two men is of inestimable value and their contributions to the aphid control program are hereby gratefully acknowledged.

⁴ The cooperation of the following growers is gratefully acknowledged: Stanley Annett and Sons, Cleveland and Co., Fred Hagan, and Putnam Brothers Company.

⁵ Formulae: (1) Insoluble copper-derris spray: A proprietary cuprous oxide 1½ pounds, derris 3 pounds (0.018 per cent of rotenone), crude soybean oil 2 quarts, a proprietary spreading and wetting agent 1 pint, in 100 gallons of water.

(2) Bordeaux-derris spray: Copper sulfate 10 pounds, hydrated lime 5 pounds, derris 3 pounds (0.018 per cent of rotenone), crude soybean oil 2 quarts, in 100 gallons of water.

(3) Insoluble copper-derris dust: A proprietary cuprous oxide (same as in (1)) 6.4 per cent, derris 15.6 per cent (0.75 per cent of rotenone), crude soybean oil 1 per cent, pyrophyllite 77 per cent.

(4) Bordeaux-derris dust: Monohydrated copper sulfate 20 per cent, hydrated lime 63.4 per cent, derris 15.6 per cent (0.75 per cent of rotenone), crude soybean oil 1 per cent.

Note: The ground derris root used in these experiments contained 4.8 per cent of rotenone and 16.7 per cent of total extractives. The dusts were mixed in a converted concrete mixer using stones. The conditioning agents were all atomized into the mixer while the materials were being blended.

10-row booms having 3 nozzles per row. These sprayers applied about 100 gallons of spray per acre per application at a fairly high pressure.

At two of the farms, horse-drawn traction sprayers were used, equipped with 6-row booms carrying two nozzles to the row. About 75 gallons of spray was delivered per acre per application and, as the nozzles were directed at the tops of the plants, the coverage of the lower leaves appeared to be less than that obtained by using a power sprayer.

On all farms the dusts were applied with a high-velocity power duster. Between 36 and 48 pounds of dust was applied per acre per application.

The aphid infestation was very light early in the season and the first insecticidal treatment was applied at the time for the second or third fungicidal coverage. From 3 to 5 applications of insecticides were made with the regular application of fungicides.

The effect of the insecticides on the aphid infestation was judged by the relative numbers of aphids surviving after the second application, when they were at their peak of abundance. On this basis, significantly fewer aphids, according to statistical analysis, survived in the plots to which derris was applied than in the plots to which only a fungicide was applied. The control of the aphid population ranged from a negative value to 96 per cent. Control was very good in some fields regardless of aphid species, the derris mixture applied, or the position of the aphids on the plants, but was unsatisfactory in other fields. Following the second insecticide application the percentage control was estimated as 64 per cent for the green peach aphid, 65 per cent for the buckthorn aphid, and 30 per cent for the potato aphid.

Field data showed that the plots treated with a fungicide plus derris produced significantly higher yields of potatoes than plots receiving only the fungicide. Each of the four derris treatments had about the same effect. The increase in yield on the derris-treated plots was 9.3 per cent or about 13 barrels per acre.

Samples from these plots were planted in the Florida Test and when the tubers were cut for planting a reading was taken on net necrosis. Tubers from derris-treated plots had 5.9 per cent with net necrosis and those from plots receiving only the fungicide had 8.0 per cent with net necrosis. At the time of the second reading for leafroll in the Florida Test plots, 32.9 per cent of the plants from

tubers from the check plots were diseased. For the plants from tubers of the derris-treated plots the percentages of leafroll were 31.6, 27.2, 25.7, and 25.5 for the application of derris-bordeaux spray, insoluble copper-derris dust, insoluble copper-derris spray, and bordeaux-derris dust, respectively. These figures indicate that in the 1941 season the use of either of the last two named insecticides was effective in reducing the spread of leafroll.

According to G. W. Simpson derris was used by a number of growers who entered seed plots in the 1941 Foundation Seed Program. The results obtained by these growers as compared with those from growers not using derris, suggests that the practice of early harvesting is much more effective in controlling leafroll than is the use of an insecticide. When derris is used the potato vines remain green later in the season. Insecticidal treatments are not effective in killing all the aphids and the ones left alive have more time during which to spread the leafroll virus if the potato vines are kept green. This is the explanation given by G. W. Simpson for the fact that these particular derris-treated plots had slightly higher readings in the Florida Test than did similar plots not treated with derris.

EARLY HARVESTING. The practice of "early harvest" has been employed for several years in the Foundation Seed Program. It is one of the most effective means of keeping the leafroll disease in check. In "early harvesting" the vines are pulled about the middle of August before the aphid infestation has become too great and before most of the disease that has been spread has had time to work down through the plant into the tubers. The results obtained on the various dates of harvesting in 1941 amply support the recommendation for "early harvesting" as a means of avoiding much of the spread of leafroll that may occur if vines remain green until normal digging time. Digging was begun on August 11 and samples were taken at two-week intervals until and including October 22. Samples were taken from two farms. The samples taken on August 11 developed 2.7 per cent of the potatoes with net necrosis on one farm and 20.1 per cent on the other farm. The potatoes dug on October 8 developed 11.9 per cent of net necrosis in the sample taken from the first farm and 55.7 per cent in the sample from the other farm. These samples were all stored at the 52° F. temperature so that the net necrosis which developed probably represents 80 or 90 per cent of the total spread of leafroll. On the first farm the

spread was more than tripled in the approximately two-month period from August 11 to October 8 and on the other farm it was more than doubled. (See Table 5 in the Appendix for complete data.) Duplicates of these samples stored at 36° F. had much less net necrosis, as would be expected. While the "early harvesting" results in a much lower yield of potatoes, it is effective in avoiding much of the spread of leafroll that normally occurs.

SEROLOGICAL, CHEMICAL AND PHYSICAL TESTS. The killing of the leafroll virus in the tuber, or merely its inactivation, would be an effective method for controlling the disease. Various chemicals and heat are being tried by A. Frank Ross but to date the results have been negative.

Were it possible to identify the disease virus in the infected tubers with reasonable accuracy these could be removed from seed stocks. It is known that tubers with net necrosis do contain the leafroll virus. However, some of the potatoes with the virus do not show net necrosis, and none of the newer varieties such as Sebago, Houma, Katahdin, and Chippewa show the net necrosis although all are susceptible to leafroll. In the Green Mountain, 24 per cent of the tubers from hills that showed rolling of the leaves, apparently due to leafroll infection early in the season, later developed net necrosis. This indicates that net necrosis is not confined to late season infection. Some evidence was obtained indicating that the ratio of leafroll tubers to net necrosis tubers was influenced by fertilizer treatment. Several physical and chemical means for detecting the virus in tubers are being tried. So far none of these have proved entirely reliable although one test has shown some promise. Leafroll and healthy Chippewas react differently when stored for relatively long periods of time at 32° F. They differ in susceptibility to mahogany browning and in the tissues affected by this defect. This reaction may be useful in the separation of diseased from healthy tubers. The accuracy and the reliability of the method, however, are yet to be established.

SEED SOURCE, FERTILIZATION, AND CULTURE. Net necrosis is a serious defect in table stock potatoes, and has been an important factor in the reduction of acreage planted to the Green Mountain variety. It would be helpful to table stock growers if some means could be found to prevent the development of this defect. This possibility is being kept in mind while attempting to develop seed stocks free of the leafroll virus.

SEED SOURCE. Potatoes from four fields were checked by Donald Folsom for leafroll spread in 1941, one field each in the towns of Hodgdon, Ashland, Mars Hill, and Westfield. Greenhouse tests in 1941-1942 showed that this disease had spread in all of these fields except the one in Ashland. The readings on net necrosis were 32 per cent, 0.5 per cent, 21 per cent, and 37 per cent, respectively, when the tubers were stored at 51° F. (See Table 6 in Appendix.) It was found also that when tuber samples from these fields were stored at temperatures optimum for net necrosis development, the net necrosis represented 95 per cent of the leafroll spread in 1941 for the field at Hodgdon, 75 per cent for the field at Ashland, 67 per cent for the field at Mars Hill, and 77 per cent for the field at Westfield. (See Table 7 in Appendix.) The storing of large quantities of seed stocks at temperatures favorable for net necrosis is not practical, of course. This method, however, might be used in a limited way to obtain a reading on leafroll content if it were found to give an accuracy of around 80 or 90 per cent, particularly in stocks suspected of having a rather high percentage infection.

CULTURE. The development of net necrosis in potatoes from the permanent plots at Aroostook Farm was correlated to some extent in 1941 with the previous crop and treatment, according to J. A. Chucka and A. Hawkins. Potatoes preceded by potatoes tended to show somewhat higher percentages of net necrosis than potatoes preceded by either crimson clover or corn. (See Table 8 in Appendix.) The differences among the various plots, however, were all too small to be of significance.

The time of harvesting the crop had a very definite bearing on the amount of net necrosis, the later the harvest the higher the percentage of net provided the vines remain green. (See Table 5 in Appendix.)

Tubers from plants sprayed with bordeaux mixture had, according to A. Frank Ross, 6.2 per cent of net necrosis as compared with 2.2 per cent in tubers from plots sprayed with Spergon, a non-copper spray. It is probable that the difference was due to the fact that the tops of the plants sprayed with Spergon died down earlier than did those sprayed with bordeaux. This conclusion checks with the results on early harvesting.

FERTILIZATION. Some fertilizers were found by J. A. Chucka and A. Hawkins to have a very definite effect on the development of net necrosis. Those containing muriate as the source of potash tended to produce potatoes with a higher net necrosis reading than did those fertilizers with potash from a sulfate source. Also, where the potash was all from the muriate the percentage of net necrosis increased as the potash in the fertilizer ratio was increased. It would appear to be the chlorine in the fertilizer that is the disturbing factor. Potatoes from plots fertilized with chemicals with no chlorine averaged 3.3 per cent net necrosis in 1941. Potatoes from plots fertilized with a mixture containing 8 per cent potash in the form of muriate averaged 9.3 per cent net necrosis. In the potash ratio test the net necrosis in the tubers from the various plots was .8 per cent, 6.2 per cent, 9.7 per cent, 8.0 per cent, and 11.6 per cent for 0, 4, 8, 10, and 12 per cent potash respectively. Other evidence that chlorine is the disturbing element is given in the "source of nitrogen" test. Potatoes from plots fertilized with ammonium chloride as a source of nitrogen had 25.7 per cent net necrosis in those from the unlimed portion of the plot and 29.7 per cent net in those from the limed portion. This compared with 12.2 per cent where nitrate of soda was used and 11.3 per cent and 13.3 per cent for limed and unlimed sections of the plot where ammonium sulphate was used. (See Table 9 in Appendix.) These results were obtained on Aroostook Farm plots. Any particular plot has received the same treatment since 1928. Results on two other farms did not check with those obtained at Aroostook Farm, there being little difference in net necrosis in potatoes on fields treated with a fertilizer containing the muriate or the sulphate of potash. (See Table 10 in Appendix.) It is felt, however, that the results on the Aroostook Farm plots are a more reliable indication of what can be expected over a period of years.

There is some indication, according to A. Frank Ross, that potatoes vary in leafroll infection to some extent with the amount of phosphate used in the fertilizer ratio. Potatoes from plots fertilized with 4-4-8, 4-8-8, and 4-12-8 produced plants with 12.5 per cent, 23.4 per cent, and 31.8 per cent, respectively, of leafroll. Should these results be verified by further tests they will be of some economic importance. Unpublished results from several years of study show that the phosphate in the fertilizer may be reduced from

8 per cent to 6 per cent without any loss in yields. Phosphates used in the fertilizer mixtures all contain some fluorine which is chemically related to chlorine.

Too much confidence should not be put in short period studies with fertilizers. The results indicating the effect of chlorides on net necrosis development, however, have checked reasonably well for two successive years. It is felt that one is safe in advising against chlorides in the fertilizers used for growing potatoes. Potash from other sources is just as effective from the standpoint of obtaining high potato yields. Also, the potatoes from plots fertilized with "pure chemicals" rank at the top in both cooking quality and starch content. The "pure chemical" fertilizer was made up of potassium nitrate, mono ammonium phosphate, and urea, there being no chlorine or fluorine in the mixture.

STORAGE TEMPERATURES. The temperature at which potatoes are stored has been found by Donald Folsom to have a very definite effect upon the development of net necrosis during the storage period. Potatoes stored at 33° F. showed 18 per cent of the tubers with net necrosis after 120 days in storage while those from the same field stored at 47° F. for the same period of time showed 40 per cent with net. Potatoes from another field had 15 per cent with net necrosis at the 33° temperature and 35 per cent at the 47° temperature after 154 days in storage. (See Tables 11, 12, and 6 in the Appendix.)

It was found also that potatoes held 10 to 30 days at 34° F. developed less net necrosis later at 47° F. than did those held for the full period at the higher temperature. A period of 30 to 90 days at the 34° temperature apparently conditioned the potatoes so that further development of net necrosis was much retarded or stopped entirely even when the bin temperature was raised to 47° F. (See Tables 13, 14, 15, and 16 in the Appendix.) These data suggest the possibility for materially reducing the percentage of net necrosis in table stock potatoes. If one can lower the temperature of his storage bin to around 33° or 34° F. soon after digging he will be able to reduce materially the net necrosis development in his stock. This procedure would enable many Green Mountain potatoes to grade U. S. No. 1 that otherwise could never make this grade. It was found also by Donald Folsom by careful checking that a potato with net necrosis usually had more than the 10 per cent waste permitted in U. S. No. 2 grade. (See Table 17

in the Appendix.) A cautionary comment should be made here relative to these low storage temperatures. They are helpful in controlling both net necrosis and stem-end browning in Green Mountains. Temperatures around 32° or 33° F., however, may cause Katahdins, Chippewas, and Sebagos to develop mahogany browning which is even more serious than net necrosis.

Stem-End Browning. Many attempts have been made to learn the nature or cause of stem-end browning. No one has been successful so far in connecting any fungus or bacterium with the development of this defect. Tests by A. Frank Ross disclosed that the concentration of latent virus is higher in stem-end browning tubers than in normal ones. It was found by further tests, however, that the latent virus was not the direct cause of stem-end browning although its presence in a potato stock may influence the amount of the defect to develop.

The serological test previously developed for the identification of stem-end browning has been studied further. The behavior of the test varies with the storage period and is most satisfactory about the time the defect develops in storage. During late winter and spring the test is complicated by the tendency of normal sera to give positive reactions.

The previous report that stem-end browning tubers contain less copper than do clear-fleshed tubers was not substantiated by the current year's results of ash analyses. Neither has any other chemical element been found in the tuber to be consistently associated with this defect.

Studies with insects failed to find any connected with the transmission of stem-end browning. Potato plots protected from insects produced tubers with 27 per cent of the defect and plots not protected had tubers of which 26 per cent had stem-end browning.

Checks by A. Frank Ross on the distribution of stem-end browning in the field disclosed that it was not uniformly distributed. In very few cases did all tubers in a single hill show the defect, usually only 1 or 2 being affected. There was some tendency for infected hills to be clumped.

Some evidence was obtained for the first time that stem-end browning seed stocks may produce a crop with more of the defect than is produced when clear-fleshed stock is planted. The averages for all plots of Green Mountains in the test were 7.3 per cent for clear-fleshed seed and 13.4 per cent for stem-end browning seed.

Similar tests with Cobblers gave negative results. The data indicate not only that there is a difference in stem-end browning and clear-fleshed seed but that seed from different sources responds differently under identical environmental conditions.

CULTURE. The Cobblers and Green Mountains grown in the Seed Spacing Variety Test on Aroostook Farm were examined for stem-end browning by A. Frank Ross. The Cobblers contained only 7 per cent stem-end browning and there was no correlation of the defect with seed spacing or size of tubers. On the Green Mountains, stem-end browning was correlated with seed spacing only on the plots where 1,000 pounds of fertilizer was added per acre. Spacings of 6, 9, and 12 inches resulted in 30.3, 41.0, and 49.5 per cent stem-end browning respectively. When fertilizer was applied at the rate of 1,250 or 1,500 pounds per acre there was no such correlation. There was, however, a correlation between tuber size and amount of stem-end browning. The Green Mountains were graded into four sizes, small, medium, large, and extra large. The averages of stem-end browning for these sizes were 25 per cent, 52.2 per cent, 64.8 per cent, and 67.5 per cent respectively. This relationship held regardless of seed spacing or fertilizer application. These results are in conflict with previous data, hence it appears that the correlation between incidence of stem-end browning and tuber size may vary from year to year.

The percentage of stem-end browning apparently varies to some extent with the time the potato crop is harvested. Samples from two fields were dug at two-week intervals in 1941 beginning August 11 and ending October 22. In the samples from one field the stem-end browning varied from 7.5 per cent for the August 11 harvesting to 18.7 per cent for the October 8 harvesting. In the other field the variation was from 6.4 per cent for the August 11 harvesting to 23.0 per cent for those harvested on September 8. These samples were all stored at 52° F. which is considered about the optimum for stem-end browning development. (See Table 5 in the Appendix.)

FERTILIZATION. The percentage of stem-end browning appeared again in 1941 to be correlated with the use of certain fertilizers. Samples from all of the fertility plots at Aroostook Farm were stored at around 50° F. In samples from plots fertilized with "pure chemicals" the highest reading of stem-end browning was 3.6 per cent. This fertilizer had no chlorine in it, being made up of potassium nitrate, mono ammonium phosphate, and urea. Potatoes

from the plot fertilized with a 4-8-12 fertilizer showed 48.2 per cent with stem-end browning. In this fertilizer the potash was all supplied from potassium chloride. In the potash ratio test the potash ranged 0 per cent, 4 per cent, 8 per cent, 10 per cent, and 12 per cent in the ratios. Potatoes from these plots had .5 per cent, 3.6 per cent, 21.4 per cent, 20.9 per cent, and 48.2 per cent respectively with stem-end browning. The potash here was all from potassium chloride. In the Sources-of-Nitrogen Test ammonium chloride produced potatoes with 20.2 per cent stem-end browning on unlimed portions of the plot and with 31.3 per cent on the limed portion. Sulphate of ammonia produced potatoes with 7.3 per cent and 17.4 per cent on the unlimed and limed plots respectively. The reading on the nitrate of soda plot was 15.6 per cent of stem-end browning.

Where potassium sulphate and potassium chloride were directly compared the potatoes from the sulphate plot unlimed had 4.7 per cent stem-end and on the limed portion 4.8 per cent. The readings on the potassium chloride plot were 12.0 per cent on the unlimed portion and 23.6 per cent on the limed portion.

Also, in the Rate-of-Application Test where the potash was all from the muriate the percentage of stem-end browning increased as the amount of fertilizer applied per acre increased. The readings were 1.6 per cent for no fertilizer, 9.6 per cent for 1,500 pounds, 21.4 per cent for 2,000 pounds, 24.8 per cent for 2,500 pounds, and 29.8 per cent for 3,000 pounds per acre. (See Tables 8, 9, 10, 18, and 19 in the Appendix for detailed data.)

There is, therefore, considerable evidence to indicate that chlorides in the fertilizer are a definite stimulus to the development of stem-end browning. The results given above point directly to this conclusion. Other results are not so clear in their indications. Tests on commercial farms are not as clear cut against the chlorides. It is felt, however, that the Aroostook Farm plots provide the most dependable data since these have received the same treatments for a long period of time. Further, all the results obtained in tests with fertilizers indicate that either the sulphate or the nitrate of potash, or a combination of the two, is just as effective a source of potash as the muriate from the standpoint of maintaining potato yields.

STORAGE TEMPERATURES. The temperature at which potatoes are stored is very definitely a factor in the development of stem-end browning. This defect varies from one field to another as was shown by Donald Folsom where potatoes from four fields were

compared during the winter of 1941-1942. This variation from one field to another frequently may be greater than the variation found at different storage temperatures. Nevertheless, potatoes from one field which developed 47 per cent of stem-end browning at 60° F. showed only 10 per cent when stored at 33° F. Apparently, the first 60 days of the storage period is the most critical for this defect. Potatoes held at 33° F. for 120 days developed 13 per cent stem-end browning while those held for 60 days at the 33° temperature and then shifted to a 52° bin for another 60 days had only 14 per cent of the defect. When held for 30 days at the low temperature and 90 days at 52° the reading was 23 per cent. However, it should be noted as indicated above that these potatoes developed 47 per cent of this defect when held at the 60° temperature throughout the storage period. Potatoes from another field which had 9 per cent stem-end browning at 60° F. had only 3 per cent at the 33° temperature. (See Tables 6, 13, 14, 15, 16, 20, and 21 in the Appendix for detailed data.) On the basis of these data and similar data in past years, therefore, it is recommended that the storage temperature for Green Mountains and Cobblers be brought down to around 33° F. just as soon as possible after digging time. In most storages the lowering of the temperature may possibly be speeded up with the use of a fan or blower at night when the air is cooler outside than inside the storage. A study is being made on this point using a thermostatic control that can be set to shut off the blower automatically when the storage reaches the desired temperature. The blowers, however, can be controlled by hand. Potato varieties such as Chippewa, Katahdin, Sebago, and Houma should not be cooled below around 36° F. since they develop mahogany browning at temperatures around freezing or slightly above. Since these newer varieties do not develop stem-end browning anyway there is no object in keeping them at extremely low temperatures.

Purple Top. The purple top disease continues to be a serious problem. Many specimens of suspicious plants have been brought in for diagnosis. Unfortunately, practically nothing is known regarding the cause of this disease. In fact there seems to be two diseases with symptoms of purple top, one which does not affect the seed quality of the tubers which grow normally and the other which affects materially the seed tubers.

About 80 fungus and bacterial cultures have been isolated by Reiner Bonde from hills affected with purple top and these are be-

ing tested regarding their pathogenicity on potato plants and their effect upon the plant.

The suspicion that rhizoctonia had some connection with this disease has, so far, not been substantiated on the basis of experiments to test this point.

So far no organism has been identified as the causal agent. The disease apparently affects all varieties but has been most prevalent in Katahdins and Sebagos. Tubers from plants affected with current-season symptoms of purple top are not suitable for seed purposes since they produce only weak plants if they grow at all. The tubers obtained from these weak plants, however, will produce nearly normal plants and tubers the following year. Tubers from purple top hills appear to grow normally provided they are dug early before the symptoms become pronounced.

Rhizoctonia. Treatments of seed potatoes by the acidulated mercury dip method were studied by Reiner Bonde and Bernie Plummer, Jr., to determine the effect of a reduction in the amount of acid in the dipping solution on its effectiveness in the control of rhizoctonia and on its retention of the mercury content after successive treatments. The standard formula requires 1 per cent of acid and 0.2 per cent mercuric chloride. The results of the 1941 studies indicate that the acid content of the solution can be reduced to 0.25 per cent without materially affecting the rapidity of loss of mercury with successive treatments or the solution's effectiveness in controlling rhizoctonia. The results show also that citric acid may be substituted for hydrochloric or acetic acid in the acidulated mercury dip solution. There was some evidence in 1941, however, to indicate that a treating solution prepared with acetic or citric acid is somewhat less effective in controlling rhizoctonia than is a solution acidulated with hydrochloric acid.

Mahogany Browning. Internal mahogany browning of potatoes is a low-temperature injury. There is some evidence to indicate that the presence of the leafroll virus in the tuber aggravates this injury in Chippewas and also results in a localization of the discoloration in the cortex of the tuber. This was discovered in studies by M. T. Hilborn and Reiner Bonde in which potatoes stored at 32° F. and at 36° F. at digging time were examined each week during the storage season. The first appearance of mahogany browning was about the middle of January. After that time the percentage of affected tubers increased to almost 100 per cent in

Chippewa which is a susceptible variety. None of this defect was found in Green Mountains stored at 32° F. or in Chippewas stored at 36° F. It would be considered good judgment, therefore, to keep the storage temperature at 36° F. or slightly above for Chippewas, Katahdins, and possibly some of the other new varieties.

Late Blight. Late blight continues to be one of the most troublesome potato diseases in this State. This disease was very severe in Aroostook County in 1941 and the loss caused by it was relatively great. A rather limited survey made during the second and third weeks of September indicated that more than half of the fields were badly infected with late blight. The disease was practically absent on a few fields which in all cases had been well sprayed throughout the season. Data secured during the harvesting season from the farms of one township indicated that approximately 5 per cent of the crop was left in the field on account of tuber decay caused by late blight. A few fields had nearly 25 per cent of the tubers infected with late blight decay. It has been estimated that about 10 per cent of the crop was lost in 1941 because of infection by this disease.

The control of late blight is a major problem for the farmers of Maine and large losses are still experienced in spite of large expenditures made for the purchase of fungicides. A curtailment of the supply of copper fungicides because of the war surely would cause much anxiety for the potato growers. It is quite possible that some growers might make more efficient use of the fungicides which they buy, in one way or another, as will be indicated.

Late blight infection was found in several places in the experimental spray field on Aroostook Farm on July 23 and climatic conditions were favorable for the general spread of the disease throughout most of the season. The plots received seven or eight spray applications during the season and the disease was well controlled by all of the copper fungicides that were under trial.

COPPER-SPRAY FUNGICIDES. The various copper fungicides for the control of early and late blight were tested by Reiner Bonde on the Houma variety in 1941 since it is considered to be even more susceptible to late blight than the Green Mountain. The disease was very prevalent in these experimental plots in 1941 so that the conditions were favorable for comparing the fungicidal efficiency of the different materials. The plots received seven applications of spray during the season, these being applied with a horse-drawn,

wheel-traction machine carrying two nozzles per row. The sprayer applied approximately 100 gallons per acre per application.

The plots treated with bordeaux mixture were considered as check plots in all comparisons including the yields per acre since this treatment has been the standard one for years. Yellow cuprocide, when used at the rate of 1 pound in 100 gallons of spray material, appeared to be the least effective of the fungicides under trial.

Plots receiving copper hydro arsenate and copper hydro arsenate-ite for blight control yielded four and five barrels respectively more per acre than did the plots treated with bordeaux. Field observations on the development of late blight infection revealed that these two materials were very good fungicides as compared with the others that were under trial. They also apparently possess some insecticidal properties and it is possible that part of the increase in yield resulted from the control of insects, particularly the Colorado potato beetle and flea beetles. Copper hydro arsenate and copper hydro arsenate-ite may prove of considerable value for spraying potatoes provided these materials can be sold on the market at a favorable price. The fact that they contain a relatively low percentage of metallic copper is in their favor, especially at a time when the supply of copper may be limited. It is possible also that these two materials may control the potato beetle satisfactorily, in which case it would not be necessary to use calcium arsenate for this purpose.

MODIFIED BORDEAUX MIXTURES. Bordeaux mixture prepared according to the 10-10-100 formula was for a number of years recommended for spraying potatoes in Maine. More recent work by Reiner Bonde has shown that the lime content in the bordeaux formula can be profitably reduced to one-half resulting in the 10-5-100 formula now being recommended. The possibility that blue vitriol and fungicides containing copper may become scarce in the near future has raised the question as to whether the copper content as well as the lime used in making bordeaux can be reduced without endangering the crop from late blight attack under Maine conditions.

An experiment was conducted in 1941 for the purpose of determining the effect on yield and late blight control of spraying Green Mountain potatoes with bordeaux prepared according to different formulae. A two-nozzle-per-row, horse-drawn, wheel-traction spray rig was used for applying the materials. The plots received

7 applications of spray during the season and approximately 100 gallons of bordeaux was applied per acre per application. The formulae tried were 10-10-100,⁶ 8-8-100, 8-4-100, and 10-5-100.

The yields from the plots sprayed with the different concentrations of bordeaux mixture were quite similar so that no particular formula stood out as superior to any other.

Early and late blight were controlled equally well by all concentrations of bordeaux mixture under trial. Both diseases were very severe in the unsprayed controls and in field plots located nearby. The results of this single test indicate that the copper sulphate in the bordeaux formula may be reduced 20 per cent with no significant reduction in the yield of potatoes. This would be especially true on farms where good spray equipment is employed and where the fields are kept well covered with spray material. It is the opinion of Reiner Bonde that the time of application together with the maintenance of a good coverage of spray material at the critical period for late blight are more important, within limits, than the particular bordeaux formula that is used.

ORGANIC SPRAY FUNGICIDES. Certain organic non-copper-containing materials were under trial again in 1941 for their possible fungicidal properties and their usefulness in the control of late blight. One material which appeared to be promising in the 1940 season appeared again in 1941 to have considerable fungicidal value. It did not control blight late in the season, however, when the weather conditions were most favorable for the spread of the disease and therefore the potato yield was seriously reduced in the plots treated with it. The plots sprayed with bordeaux yielded 157 barrels per acre in comparison with 141 barrels per acre for another of these fungicides.

Aphids and other insects were not plentiful in the plots included in this experiment; therefore it was impossible to determine whether the organic material possesses insecticidal properties.

COPPER FUNGICIDES COMBINED WITH ROTENONE. The prevalence of leafroll and net necrosis in many fields of potatoes recently grown in Aroostook County has made it desirable to attempt to reduce the aphid population in the field with an insecticide. There is more economy of labor if the fungicide and the insecticide can be applied in one field operation. Experiments were con-

⁶ Copper sulphate, lime, and water respectively.

ducted in 1941 by Reiner Bonde and G. W. Simpson to determine whether or not rotenone is compatible with certain commonly used copper fungicides, and whether or not such a combination spray formula is practical.

The plots were sprayed with a tractor-power-take-off machine and received eight applications for the season. Rotenone, in the form of ground derris root, was added to all spray applications except the first one. The fungicides under trial were bordeaux 10-10-100, bordeaux 10-5-100, Basi-cop 5-100, spray-cop 6-100, and yellow cuprocide 1.5-100.

The yields obtained from plots receiving the different treatments are summarized in Table 24 in the Appendix. The addition of rotenone to the fungicide spray resulted in an increase of from 9 to 17 barrels of potatoes per acre.

Spraying with rotenone in combination with a copper fungicide can be expected to result in an increased yield of the crop sufficient to pay for the added cost of the insecticidal materials. Its use may not, however, reduce the insect population sufficiently to lower the amount of spread of leafroll and other virus diseases. Further work should be done to test other fungicidal and insecticidal combinations for their ability to reduce the amount of disease spread. It is possible also that the equipment could be improved from the standpoint of its efficiency in the application of fungicides and insecticides.

DUST-OIL VAPOR FUNGICIDE AND INSECTICIDE. An experiment was conducted in 1941 by Reiner Bonde and G. W. Simpson to test the efficiency of a "Dust-Oil Vapor" fungicide and insecticide in controlling the blight diseases and insects. The machine for applying this material is known as a "Vapo-duster," is manufactured by the Root Duster Company of Cleveland, Ohio, and was supplied to the Station by the California Spray Chemical Company of Elizabeth, New Jersey. With this equipment the copper-containing dust is expelled by tractor power with force into the potato foliage through one set of openings on the spray rig and the oil mist through another set of openings. This oil may contain an insecticide in the form of a combination of extracts of rotenone and pyrethrum and aids in making the dust adhere to the foliage.

The plots received six applications of the combination of fungicide and insecticide the first being made on July 23, when an

occasional lesion of late blight could be found in the plots. The treatments given were dust and oil, dust and oil plus an insecticide, bordeaux 10-5-100, and bordeaux plus rotenone. The first three materials were applied with the "Vapo-duster" and the last was applied with a tractor power sprayer.

The yield rates for the treatments which included an insecticide were significantly greater than for those without the insecticide. The plots treated with bordeaux 10-5-100 without an insecticide gave the lowest yields of all. The difference in yield rate between the two series of plots treated with bordeaux and the corresponding dusted plots might have been due to some extent to the differences in plant injury caused by the machines making the applications. The wheels of the "Vapo-duster" outfit apparently caused less plant injury than did those of the regular spray rig. The insecticide applied with the "Vapo Dust" increased the yield 7 barrels per acre and rotenone added to bordeaux increased the yield 14 barrels per acre.

On Aroostook Farm, both the "Vapo Dust" and bordeaux gave good control of late blight, in spite of the fact that a trace of infection was present when the experiment was begun. The dusted plots began to mature approximately a week before those that were sprayed. The plots that received the insecticide in addition to the fungicide remained green somewhat longer than did those which did not receive the insecticidal applications.

Experimental data on studies in late blight control are given in Tables 22, 23, 24, and 25 in the Appendix.

GREEN MANURE CROPS

Eight different crops (sunflowers, corn, millet, buckwheat, sudan grass, crimson clover, oats, and soybeans) were compared by J. A. Chucka and J. L. Harrington as annual green manure crops for potato rotations on four farms in central Maine. The yield for these crops in organic matter produced, as an average for the four farms, ranged from 7,686 to 3,706 pounds per acre. The crops ranked in yield in descending order as listed above with sunflowers yielding the highest. Several fertilizer treatments are being compared on two of these farms on a fairly large area each of corn and millet. Applications of fertilizer were made both in the

spring prior to seeding and again in the fall when the crops were plowed under. These areas are to be planted to potatoes in the spring of 1942 and potato yields will be taken to determine the relative value of the various fertilizer treatments.

At Aroostook Farm, crimson clover and field corn are being compared as green manure crops in a two-year rotation and these are being compared with potatoes grown every year. Two levels of fertilizer application (1,000 and 1,500 pounds per acre of an 8-16-20) are being used on these plots. On some of the plots in the two-year rotation all of the fertilizer is applied to the potato crop and none to the green manure crop. On other plots part of the fertilizer is applied to the green manure crop and the remainder to potatoes. These plots were started only two years ago and should be continued for several more years before attempting to judge either the value of growing a green manure crop or the proper time or place of applying the fertilizer. However, it may be of interest to report the results obtained thus far. Corn produced roughly twice as much organic matter as did crimson clover. Corn also responded to fertilizer added to the green manure crop to a much greater extent than did the crimson clover. Potato yields following either corn or crimson clover were higher than those following potatoes. Thus far, however, yields of potatoes following crimson clover were somewhat higher than those following corn in spite of the fact that more organic matter was turned under where corn was used as a green manure crop. Also, potato yields were somewhat higher where all the fertilizer was applied to potatoes and none to the green manure crop than they were where part of the fertilizer was applied to the green manure crop and the remainder to the potato crop.

It is possible that better results might be obtained from the use of corn or other nonlegume green manure crops if more nitrogen were applied either in the growing of the green manure crop or at the time it is turned under.

FERTILIZERS

Permanent Plots. All treatments on the permanent plots at Aroostook Farm produced higher yields in 1941 according to J. A. Chucka, A. Hawkins, and J. L. Harrington than were secured during each of the three preceding years. Differences in yield

among the various treatments were in general the same as in previous years. The plot yields again indicated that more phosphoric acid is being used in potato fertilizers than is necessary to obtain maximum yields.

Potash Source and Ratio. Three different sources and four different rates of potash were compared in a test conducted on two farms in Aroostook County in 1941. The fertilizers with 10 per cent potash produced slightly higher yields than did the fertilizers with 8 per cent potash. Raising the potash above 10 per cent did not increase potato yields. Fertilizers with sulfate of potash and with combination sources of potash produced somewhat higher yields than did fertilizers with muriate of potash as the only source of potash.

Hi-Lo Fertilizer Placement. The standard band placement of fertilizer was compared with the so-called Hi-Lo placement using two grades of fertilizer and two rates of application on two farms in Aroostook County. The Hi-Lo placement consisted of placing one band of fertilizer at about the level of the seed piece and the other band two or three inches below it. In this Hi-Lo placement the amount of fertilizer placed in the two bands was equal in one treatment and unequal ($\frac{1}{4}$ in the upper band and $\frac{3}{4}$ in the lower band) in another treatment. None of these variations in placement produced a significantly higher yield than the standard placement method. The fertilizers used were 8-16-20 and 8-12-20 and the rates of application were 1,000 and 1,500 pounds per acre. The 8-12-20 fertilizer produced as high yields as the 8-16-20 or higher at both rates of application and in all placement methods. This substantiates the data from the permanent plots indicating that more phosphoric acid is used in potato fertilizers than is necessary.

Concentrated Fertilizer. Nine different 8-16-16 formulae were compared with one 4-8-8 formula. The 8-16-16 formulae varied in content of calcium, and in sources of nitrogen and magnesium, and the test was conducted on two farms in Aroostook County. The formulae without nitrate nitrogen tended to produce somewhat lower yields than formulae with other nitrogen sources although the differences were not significant. The variations in calcium content and variations in source of magnesium had no measurable effect on potato yields.

Starter Solution. Starter solutions consist of a relatively small amount of readily available plant nutrients added in solution directly to the seed or transplanted seedling. These solutions have been used with considerable success in recent years on such transplanted crops as tomatoes, cauliflower, and cabbage. Several rates of application on potatoes were tried on two farms during the past year, one in Aroostook County and one in central Maine. The results obtained indicate that some increase in yield of potatoes may be secured with the use of starter solutions but that the increase is too small to warrant the extra expense of these materials.

Fertilizer Rate and Ratio. A study was made comparing four rates of 8-16-20 and comparing grades of fertilizer varying in percentage of nitrogen, phosphoric acid, and potash. The test was made on three farms in central Maine. Due to the variation in the amount of rainfall in the areas where these tests were located the results obtained differed from one farm to another. In Waldo County the potato yields actually were lowered by increasing the amount of an 8-16-20 fertilizer applied at a rate above 750 pounds per acre. In southern Piscataquis County the yields secured with different amounts of fertilizer were about the same. In Penobscot County, at Lee, where ample rainfall came during the growing season, the potato yields increased with each increase in the amount of an 8-16-20 fertilizer applied. Approximately a 1-2-2 ratio of nitrogen, phosphoric acid, and potash produced the highest yields as an average for the three farms.

Data on the results of 15 years' study with fertilizers on the Aroostook Farm permanent plots are now in manuscript form and will be published shortly. A copy of this bulletin may be had upon request.

Absorption of Nutrients by Different Varieties of Potatoes. The time in the development of the potato plant when it uses the various fertilizer elements is important from the standpoint of the materials to be used in making up the fertilizer. Three years' results are available on studies made by Arthur Hawkins on the absorption of nutrients by four varieties of potatoes. In general it may be said that potato plants capable of producing upwards of 400 bushels (145 barrels) per acre, absorb about 120 to 160 pounds of nitrogen, 25 to 30 pounds of phosphoric acid, 200 to 250 pounds of potash, 60 pounds of calcium oxide, 30 pounds of magnesium

oxide, and about 10 to 12 pounds of sulfur in the process of producing this per acre yield.

The Green Mountain variety absorbed about 70 per cent of its total consumption of plant nutrient elements during the season between 50 and 80 days after planting. The earlier varieties, Cobbler and Chippewa, usually emerge and make more rapid growth early in the season than do the later-maturing varieties, and the period of more rapid absorption of nutrients occurred with these two varieties about one week earlier than for the Green Mountain variety.

Nitrification of Different Sources of Nitrogen. Urea nitrogen was found by Arthur Hawkins to be nitrified more rapidly than ammonium sulfate. This was true even if calcium carbonate (CaCO_3) was added to the ammonium sulfate mixture to the extent of balancing its equivalent acidity. Both compounds were found to nitrify more rapidly than the natural organic nitrogenous materials.

Movement of Nitrogen in the Soil. Nitrate nitrogen was found by Arthur Hawkins to be very mobile in the soil under field conditions, moving below or above the point where it was placed depending upon the movement of soil water. Following rains early in the season, nitrate nitrogen was found to move 4 to 6 inches below the point of application. During dry periods in July and August it moved upward to 8 inches above the position where it was placed (in bands to simulate field practice in potato fertilization).

SEED SPACING AND VARIETIES

The matter of seed spacing, or in effect the rate of planting, of potatoes is of considerable importance. Some varieties apparently give better performance when the seed pieces are planted relatively close. Since there is an increasing demand for seed stock having medium to small sized tubers, potatoes grown for seed probably should be planted closer than when grown for table stock.

Comparisons of the yielding ability of eight varieties of potatoes at three different seed spacings and at three levels of fertilizer application were made by J. A. Chucka, Arthur Hawkins, and J. L.

Harrington in 1941. The seed spacings used were 6, 9, and 12 inches. The rates of fertilizer application were 1,000, 1,250, and 1,500 pounds per acre of an 8-16-20 fertilizer. The test was conducted on Aroostook Farm, at Presque Isle, and on the Smith Farm, at Stillwater.

Considering the yields produced as an average of the three spacings and an average of the three rates of fertilizer applied, the range in field-run yields for the eight varieties at Presque Isle was from 184 to 138 barrels per acre. The rank of the varieties in descending order was Earlane #2, Katahdin, Sebago, Chippewa, Warba, Houma, Green Mountain, and Irish Cobbler. On the same basis the yield range of the eight varieties at Stillwater was from 158 to 96 barrels per acre and the rank of the varieties in descending order was Earlane #2, Chippewa, Sebago, Houma, Katahdin, Green Mountain, Irish Cobbler, and Warba. Relatively close spacings nearly always produce higher yields of field-run potatoes than do the wider spacings. This does not necessarily hold true, however, when yields are calculated on the basis of U. S. No. 1. When yields were based on U. S. No. 1 potatoes rather than on field-run such varieties as the Green Mountain and the Katahdin receive a relatively higher rank and such varieties as Houma and Warba receive a relatively lower rank. Data are given in Table 26 in the Appendix.

POTATO BY-PRODUCTS

Potato by-products, particularly starch, have been a substantial source of income to potato growers in Maine during recent years. It can be assumed that the sale of table stock and seed potatoes will continue to be the major source of income for the potato industry. The manufacture of potato starch and any other by-products that may be developed will, however, be of considerable value to the potato industry if these enterprises can be properly integrated. It is with this thought in mind that studies have been continued on by-products. An improvement in the quality of starch or an improvement in the methods of manufacture to increase the starch yields makes it possible for the manufacturer to pay the grower higher prices for potatoes for manufacture.

Starch Factory Potatoes. Thirty-eight samples of starch

the interval May 1, 1941, and April 30, 1942. The average starch content of tubers for the entire year was 14.1 per cent. The range was 10.5 to 17.5 per cent. For the previous year the average was 13.4 per cent. The quality of tubers and No. 1 or better potatoes going to starch factories was very poor considering the quality of the seed. There were fewer "blacks" and "blues" and more "mushy" and "lumpy" tubers. The "lumps" contained considerable malingerous material, but otherwise the potatoes are comparable to those of last year. There were fewer "blacks" and "blues" and more "mushy" and "lumpy" tubers. The "lumps" contained considerable malingerous material, but otherwise the potatoes are comparable to those of last year. There were fewer "blacks" and "blues" and more "mushy" and "lumpy" tubers. The "lumps" contained considerable malingerous material, but otherwise the potatoes are comparable to those of last year.

I must state it over in factory reports and relatively few small sound potatoes. Most samples contained one and two-thirds potatoes, second growth "blacks," "in stage," and subnormal. The subnormal and "blacks" contain a little less starch than normal average sized potatoes. Some samples had a high percentage of diseased "firsters" which contain little starch. Very little net nematode and some other nematode was found in some samples. There were no "blacks" and "blues" present in the samples throughout the year and some "mushy" was present. Much of bacterial rot was present in the samples and some "mushy" was present in the samples.

Starch Analysis. Analyses of 45 samples of starch were conducted and the results are given as follows:

There has been considerable change in the processing of starch in various factories, reasons for variations in the part of work and how many of the difficulties could be overcome. The industry is producing a better quality starch, especially with a higher yield and value. Much thought has been given by starch manufacturers in the analytical figures obtained and many have expressed a goal at which to aim in their own efforts.

Other analyses made included three samples of water, one of which was found to contain a small amount of iron and other minerals.

2 of dextrin, 2 of waxy starches, and 11 samples of potato grades with wet and dry bases. The potato waxy starch, when containing 24 hours, about 1.6 per cent mineral matter, 9 per cent water, about 0.16 per cent nitrogen, or 1.1 per cent protein, 2.1 per cent crude fiber, 9 per cent nitrogen-free extract, non-cellulose carbohydrates, and about 0.1 per cent water-insoluble matter. The water content was about 6.2.

	Waxy	Waxy	Waxy
	Starch	Starch	Starch
Dextrin %	2.0	2.0	2.0
Total solids by difference %	94.0	94.0	94.0
Ash %	0.54	0.45	0.40
Starch (water free basis) %	94.5	94.5	94.5
Protein (nitrogen free basis) %	1.1	1.1	1.1
Granule size, av., mm.	32	42 from 100	32
Ash, gram.			
(cc 0.1 N NaOH per 25 g.)	1.6	5.4	1.1
Sp. grav., max., 5 g. per dm.	5.5	2.01	5.5
" " " x 2.5 times	7.5	2.40	8.5
Sieve test for powdered samples			
100 mesh %	1.4	2.1	1.1
100 to 200 mesh %	2.5	2.5	1.1
finer than 200 mesh %	95.5	95.4	97.8
Protein, % wet	1.1	1.1	1.1
Protein, % dry	1.1	1.1	1.1
Reference numbers	1.1	1.1	1.1
Wet weight of 100	1.1	1.1	1.1
Starch, %	1.1	1.1	1.1

Commercial samples of starch have been examined separately for fat, fiber, nitrogen, and protein. A fine quality starch is free of fat, fiber, and protein and nitrogen. Poor quality starches contain a little of these substances. Practically all potato starches have a slight protein content which is due to a trace of oil which is removed in the starch processing. A good quality starch will have a slight "oil" and "protein" content, but is suitable for good quality starch.

Starch from potato. These starches are produced from potatoes in the dry state and are of a fine quality. The starch is obtained from potatoes which are grown in the potato fields and are of a fine quality.

ply of potatoes go to factories. This was near the end of September. The 1940 crop total diversion payment cars was reported as 13,402. There were probably 1,600 cars of non-diversion or cull potatoes of the 1940 crop that went to starch factories, making a total grind estimated at about 15,000 cars. There will probably be about 10,000 cars of the 1941 crop ground in a total of shipments with seed and table stock and starch potatoes of about 48,000 cars.

Starch Market and Price. The starch market has been very good. Some manufacturers turned down export orders because they could not supply their own regular customers. Although some were eager to push up the price, the better companies kept price down to as low a level as possible in order to keep their marginal buyers, so important under normal conditions.

NEW YORK PRICE IN DOLLARS PER POUND

		In car lots	In less than car lots
September 1941	Potato starch dextrin	0.0850	0.0950
April 1942	" " "	0.0950	0.1175
September 1941	Potato starch	0.0585	0.0710
April 1942	" "	0.0637	0.0760

Starch in storage, unsold, is at a low tonnage figure. During the spring of 1942, freight rates were increased by Federal edict and starch manufacturers had to increase New York and Boston prices to offset it.

Pulp Investigations. The work on waste starch factory potato pulp was carried on more intensively as soon as drained pulp was available. Dairy, sheep, cattle, and hog men were invited to get the pulp and to try it out. They were given some feeding rations, which had been checked by Professor Cairns of the College of Agriculture. Some potato growers were asked to try the pulp on their potato land. After the sulfur dioxide treatment of the pulp and thorough washing with well water, little if any disease should carry over. The waste potato pulp, upwards of 10,000 tons on a dry basis, should not go into streams but should be used as a cattle feed, or, at least, go back on the land.

German Potato Varieties. Ten varieties of German potatoes and Mountains, Katahdins, and Houmas were grown at Presque

Isle by Dr. Clark of the U. S. Department of Agriculture in a yield test consisting of five replications. Samples of these potatoes were analyzed for starch (see Table 27 in the Appendix). The starch content of the five replications was in good agreement. Although some of the German varieties contained 20.4 per cent starch, the Mountains contained 18.5 per cent and yielded a little more starch per acre (about 5,100 pounds) than did the best German variety (about 4,700 pounds). The Mountains also were the largest potatoes. There were no signs of disease in any of these thirteen lots of potatoes. The Katahdins and Houmas each contained 15.4 per cent starch and yielded 3,550 and 4,240 pounds starch, respectively, per acre.

ECONOMICS OF THE POTATO INDUSTRY

Farm Organization and Costs and Returns in Producing Potatoes in Central Maine, 1938. Farm returns, costs, and practices on three types of farms producing potatoes in central Maine were obtained by W. E. Schrumpf. Detailed information on farm acreage, crops, livestock, capital, receipts, expenses, and net farm income, as well as on all the costs and returns in potato production was obtained concerning the three types of farms producing pota-



FIG. 6. Typical potato harvesting scene in Aroostook County, Maine.

atoes commercially in the area. An analysis of the data shows that the three types, on the basis of the proportions of cash income from the various farm enterprises, are potato farms, livestock farms, and general farms.

The farm acreage of all the farms averaged 255 acres of which 74 acres was cropland. Potatoes, hay, and grain were the principal crops supplemented by beans, sweet corn, and peas. There were, on the average, 8.3 acres of potatoes per farm on the livestock farms, 8.5 acres on the general farms, and 17.3 acres on the potato farms.

Dairy animals, which comprised most of the livestock, averaged 8 per farm on the potato farms, 12 on the general farms, and 20 on the livestock farms.

The farm income (the difference between the farm receipts and the farm expenses) was largest on the livestock farms in 1938, averaging \$918 per farm compared with \$607 on the general farms and \$170 on the potato farms.

The cost to the farmer of growing, harvesting, storing, and selling potatoes was \$1.36 per barrel on the potato farms, \$1.54 on the general farms, and \$1.74 on the livestock farms.

On the livestock farms, in 1938, the average farm income was larger than on the potato farms in spite of the fact that (because of higher yield rates and larger acreages) the per barrel cost of potatoes was smallest on the potato farms. On the livestock farms more efficient use was made of labor and capital than on the potato farms. The Maine farm price of potatoes in 1938 was about the same as the average of the 10 years prior to 1938. In general, on the potato farms an increase in the size of the dairy enterprise would have supplemented the farm income. On the livestock farms, on the other hand, higher yield rates and somewhat larger acreages of potatoes would have put the cost of production in more favorable relationship to the price received. The general farms were intermediate in these respects.

Costs of Producing Potatoes in Central Aroostook County, Maine, 1940. Information on the cost of producing potatoes was obtained by W. E. Schrumpf for 1940 on 178 farms in central Aroostook County. Partial analysis of the information obtained shows that trends in the area in relation to ten years ago, when a similar study was made, are (1) an increase of 16 per cent in the

potato acreage and of 14 per cent in the number of livestock per farm, (2) a decided shift from Green Mountain potatoes to other varieties, especially Katahdin and Chippewa (ten years ago the Green Mountain variety comprised 80 per cent of the potato acreage compared with 44 per cent in 1940), (3) a decrease of about 5 per cent in the proportion of farms using horses and a corresponding increase in the proportion using tractors and trucks, (4) a decrease of about 8 per cent in the amount of man labor in producing an acre of potatoes, and (5) a slight decrease in the cost of production.



FIG. 7. Unloading potatoes at farm storage.

Potato-Harvest Labor in Aroostook County, Maine, 1941. Labor at harvest time is one of the most important items in the management of a potato farm. The period of time for harvesting the crop is relatively short normally and unfavorable weather conditions may shorten it even more. Information representing 1,708 workers was obtained by W. E. Schrumpf and Smith C. McIntire⁷ during the 1941 potato harvest season. More than one-fifth of the

⁷ Cooperating with the Maine Agricultural Experiment Station in this study were the Maine Employment Service, the Maine Agricultural Extension Service, the Maine State Department of Agriculture, and the Bureau of Agricultural Economics of the United States Department of Agriculture.

potato pickers were less than 14 years of age, and nearly one-half of them were less than 18 years of age. Women and girls comprised more than one-third of the number of potato pickers. The average of 700 barrels of potatoes per picker during the harvest season in 1941 is probably as high as can be expected in the future years of the present emergency because (1) the harvest season is not likely to be longer, (2) more women and children are likely to take the place of men leaving to go to other civilian occupations and to the armed services. Workers having the physical ability and the skill to handle barrels and potato harvest-harvest machinery (comprising 35 per cent of the harvest-labor force in 1941) will be especially difficult to obtain. A report of this study in detail has been published as Maine Agricultural Experiment Station Miscellaneous Publication No. 568 under the title, "Potato-Harvest Labor in Aroostook County, Maine, 1941." A copy of this publication may be had upon request.



FIG. 8. Unloading potatoes at track storage.

MARKETING MAINE POTATOES

The efficient marketing of the potato crop is of vital importance to the entire industry. Due to the many problems in the marketing

of potatoes and to the many interests associated with the industry, the situation has often been confused and many varied suggestions have been offered for improvement.

Potato growers for many years have been alert to the use of new equipment and machinery, to the latest cultural methods, to new varieties, and in general to the lowering of the costs of producing potatoes per barrel. Too often growers have considered their work practically completed with the production of the crop. Marketing was only incidental and involved merely the disposal of the potatoes grown. It is imperative to consider that the problems of an enterprise like potatoes consist not only of producing the crop at the lowest possible cost but to market it by the most efficient marketing methods. It is only by both efficient production and efficient marketing methods that growers can hope to obtain the best returns from their labor and capital investments. While many farmers may not expect or hope to enter the field of marketing potatoes, they should maintain a continuous interest in the many aspects of the marketing processes. It should be recognized that there is a close relationship and often an over-lapping of production and marketing problems confronting the industry. The marketing problems for potatoes really begin in the production of the crop and end with the potatoes on the consumer's table.

Information on the practices of shippers and the costs of some of the more important operations was obtained by Charles H. Merchant⁸ for the 1940-41 marketing season.

Since this study was undertaken, war has been declared on the United States by Germany, Italy, and Japan. In conducting this Second World War to a victorious end, many changes will be made in our way of living. Some of these changes will affect the marketing of the potato crop. Already rigid restrictions have been placed on burlap for new bags and on automobile tires. Other changes

⁸ This study has been made possible through the cooperative effort of the Maine Agricultural Experiment Station and the Potato Industry Tax. The author wishes to express his sincere appreciation for the splendid cooperation of potato growers and shippers; to Charles M. White, State Department of Agriculture, Augusta, Maine; to Mrs. Simonds, Bureau of Taxation, Augusta, Maine; and to many others who have furnished information for the study. The author was assisted in the field by Bertrand E. Blanchard, Walter E. Hanley, Donald M. Kilpatrick, and Keith M. Thompson.

during the war period will affect the industry and the marketing of the crop.

The suggestions for the improvement of marketing potatoes will be grouped under four general headings: (1) standardization of product, (2) cutthroat competition, (3) dealer service and publicity, and (4) research work.

Standardization of Product. One of the outstanding marketing problems facing the potato industry is that of standardization of its product. It is recognized that it is desirable to have several different qualities of potatoes to meet various consumer demands. Also, it is not practical to standardize each potato quality to the same extent as manufactured foods. However, the average consumer desires more uniformity among the potatoes of the same package and more uniformity between packages of the same lot of potatoes. This would involve more careful grading and sizing of potatoes, especially those going into consumer packages. While this would probably involve an additional cost to the shippers, the industry would probably benefit from it through improved reputation and increased demand for Maine potatoes. The potato industry may find it advantageous to establish the better grades somewhat superior to the Federal specifications.

The inspection service is a very important phase in the standardization of potato qualities. At present approximately 50 per cent of the potato shipments are inspected at shipping points. This service has greatly aided in the standardization of potato quality and more general use of the service should be considered by growers and shippers.

In the consideration of standardization, attention should be given to potato varieties. Many growers and shippers think in terms of the Green Mountain variety as a standard of quality. However, it is apparently becoming more and more difficult for many growers to produce this variety free from net necrosis and stem-end browning. Although new improved varieties are desirable, they should not be introduced on the market until sufficient time has elapsed for their qualities to be known.

In the plan for standardization of quality attention should be given to both nearby and distant markets. Local markets or other markets should not be the dumping ground for inferior potatoes unless these markets demand such quality.

Under normal conditions it would have been desirable for potato shippers to consider the advisability of shipping a larger percentage of their potatoes in consumer packages. Such packages, if standardized, would represent a real advertising feature for the industry. However, under the present emergency conditions it may be necessary to forego temporarily such a consideration.

Cutthroat Competition. Our economic way of living is based quite largely upon competition. However, it is recognized that united action is needed in the solution of many problems. Too little competition is undesirable as it often leads to uncontrolled monopolistic practices while too much competition is equally undesirable as it leads to sharp practices and duplicated efforts which are costly. Many industries have experienced in one way or another either too much or too little competition. Usually when there is too much competition there is a tendency for some individuals to be eliminated or some concerted action is taken by the most of the individuals. There seems to be too much competition among potato growers in many producing areas and too little competition in a few areas for the best interest of the industry.

Many shippers are forced by the keen competition to pursue policies which appear expedient for the present but lack foresight as to the future of the potato industry. This is a natural situation and perhaps shippers should not be criticized too severely. However, the present system of marketing is very costly due to duplicated effort on the part of shippers. But what is perhaps more important, the present system does not lend itself readily to the development of markets for Maine potatoes. Further, attempts to reduce the costly duplicated services may come from growers and shippers in Maine or from interests in the terminal markets. This is an important question for growers and shippers to consider.

With many competing shippers, the difficulty of marketing a standardized product is greatly increased. Also, such problems as the transportation of potatoes, market containers, inspection service, and others do not receive the attention and concerted effort they rightly deserve.

Dealer Service and Publicity. While the scope of this study did not include any phase of dealer service work or the publicity of Maine potatoes, it is recognized that they have a place in a coordinated program for the potato industry. It seems logical that Maine growers and shippers should first standardize their products

in order to effect the best tangible results through dealer service and publicity work.

Dealer service men are in a position to inform growers and shippers of various market conditions and to acquaint men in the markets with growers' and shippers' problems. These men are not only ambassadors of good will but are in a position to offer ideas and suggestions for the improvement of market conditions which may be put into effect by potato shippers in production areas and by various dealers in the markets.

Research Work. No industry can develop faster than its leaders and these leaders need information and authentic facts to aid them in their thinking and in their actions. The entire industry, from the smallest grower to the largest shipper, should take an active interest in the problems of both production and marketing. In fact, the most satisfactory returns from potato production will depend on a well balanced and coordinated program of production and marketing. Each of these is dependent upon the other for maximum efficiency.

What effect or what changes the Second World War may bring to the potato industry is beyond the comprehension of any of us. However, it is impractical to delay our fact finding until the war is won. Rather, it would appear practical to render such aid as is possible during the emergency and make preparations for the post-war period. If this is logical thinking, the industry needs continuous research on its important problems. Along production lines, investigational work is needed on the production of improved varieties, on cooking and the nutritional value of potatoes, better control methods for net necrosis and other diseases, on increased work on soil conservation, on farm management problems resulting from the emergency, and on many other problems of a production nature.

In marketing, information is needed on such problems as the probable availability of containers in which to ship potatoes to market during the emergency, transportation problems especially rail shipments (possible car shortage and delays in transit), consumer preferences for potatoes and other commodities during the emergency, on agricultural credit and prices, on grading and sizing of potatoes, and many other marketing problems. During the duration of the Second World War many new problems are likely to arise and our research groups should have as much information as possible to aid the industry.

The results of the study on which the foregoing conclusions are based were published in Miscellaneous Publication No. 569 of the Station, a copy of which may be had upon request.

PUBLICATIONS

Following is a list of publications giving the results of research on various phases of the potato industry. Any of these may be had upon request.

- Comparison of Apparently Healthy Strains and Tuber Lines of Potatoes. Me. Agr. Exp. Sta. Bul. No. 358.
- Isolated Tuber-Unit Seed Plots for the Control of Potato Virus Diseases and Blackleg in Northern Maine. Me. Agr. Exp. Sta. Bul. No. 370.
- A Study of the Organization and Management of Potato Farms in Aroostook County, Maine. Me. Agr. Exp. Sta. Bul. No. 378.
- A Study of the Organization and Management of Potato Farms in Central Maine. Me. Agr. Exp. Sta. Bul. No. 379.
- Costs and Returns in Producing Potatoes in Aroostook County, Maine. Me. Agr. Exp. Sta. Bul. No. 390.
- Costs and Returns in Producing Potatoes in Central Maine. Me. Agr. Exp. Sta. Bul. No. 392.
- Bacterial Wilt and Soft Rot of the Potato in Maine. Me. Agr. Exp. Sta. Bul. No. 396.
- Aphids and Their Relation to the Field Transmission of Potato Virus Diseases in Northeastern Maine. Me. Agr. Exp. Sta. Bul. No. 403.
- Farm Organization and Costs and Returns in Producing Potatoes on Farms in the St. John River Area of Aroostook County, Maine, 1937. Me. Agr. Exp. Sta. Bul. No. 406.
- Results of Testing Some Laboratory Methods for Possible Use in the Detection of Virus Diseases in Potato Tubers. Me. Agr. Exp. Sta. Bul. No. 407.
- Potato Virus Disease Studies with Tuber-Line Seed Plots and Insects in Maine 1927 to 1938. Me. Agr. Exp. Sta. Bul. No. 410.
- Marketing Maine Potatoes. 1. A Preliminary Report of Consumer Preference for Potatoes in Boston, March 4 to April 6, 1940. Me. Agr. Exp. Sta. Misc. Publ. No. 561.
- Marketing Maine Potatoes. A Preliminary Report on Interregional Competition of Maine Potatoes on the Boston Market. Me. Agr. Exp. Sta. Misc. Publ. No. 563.
- A Preliminary Report on Selling and Shipping Maine Potatoes. Me. Agr. Exp. Sta. Misc. Publ. No. 569.
- Marketing Maine Potatoes. Retail Distribution of Potatoes in the Boston Metropolitan Area, March, 1940. F. C. A. Misc. Report No. 26.

Marketing Maine Potatoes. Purchase and Use of Potatoes and Substitutes in Homes of Boston Consumers, March 4 to April 6, 1940.

F. C. A. Misc. Report No. 27.

Marketing Maine Potatoes. Organization and Market Practices in Maine and Boston. F. C. A. Misc. Report No. 31.

Marketing Maine Potatoes. Boston Retail Prices as Associated with Types of Packages, Retailers, and Consumer Incomes, February 26 to April 6, 1940. F. C. A. Misc. Report No. 36.

APPENDIX

TABLE 1

Ring Rot in Plants Developing from Diseased Tubers which Survived in the Field During Winter of 1940-1941

Field No.	Protection ¹	Number of tubers planted	Number of plants produced	Tubers whose plants developed ring rot ²
				Per cent
1	Protected	100	65	45
	Not protected	100	71	51
2	Protected	200	149	51
	Not protected	200	135	46
3	Protected	100	82	42
	Not protected	100	80	57
4	Protected	200	150	52
	Not protected	200	147	53

¹ All tubers were placed in a trench six inches below the soil surface and covered with soil to the surface level. Part of each lot was further covered with 2 inches of weeds to serve as partial protection against cold.

² Per cent based on number of diseased tubers that were planted, not on plants produced.

TABLE 2

A Summary of the Number of Lots of Seed by Variety Entered in the 1941-1942 Florida Test and the Number of Lots Recommended for Planting as Certified Seed and Table Stock in 1941

Variety	Number of lots tested	Recommended for table stock seed ¹	Recommended for certified seed ²
Bliss Triumph	7	3	2
Chippewa	33	16	10
Earlaine #2	1	0	1
Green Mountain	129	60	49
Houma	31	2	29
Irish Cobbler	77	30	36
Katahdin	71	7	60
Pontiac	1	0	1
Sebago	44	13	29
Warba	2	2	0

¹ Not more than 10 per cent leafroll.

² Disease not exceeding 2 per cent in leafroll and 3 per cent in mosaic.

TABLE 3

*Summary of Acreage Represented by Samples Entered in
1941-1942 Florida Test and Acreage Represented by
Samples Having Indicated Disease Readings*

Variety	Acreage of each variety entered	Recommended for certified seed ¹	Recommended for table stock seed ²
Bliss Triumph	78.0	18.0	51.5
Chippewa	484.8	84.5	209.3
Earlaine #2	4.4	4.4	0
Green Mountain	2008.6	717.7	932.0
Houma	136.0	122.5	13.5
Irish Cobbler	1260.9	551.8	592.5
Katahdin	762.5	611.0	132.5
Pontiac	1.0	1.0	0
Sebago	274.3	171.0	100.0
Warba	12.0	0	12.0

¹ Disease not exceeding 2 per cent in leafroll and 3 per cent in mosaic.

² Not more than 10 per cent leafroll.

TABLE 4

Aphid Species Collected on Crop Plants in Aroostook County, Maine—1941

Common name of insect	Scientific name	Total number of adults obtained in all collections from			
		Potatoes	Clover	Peas	Young clover ¹
The buckthorn aphid	Aphis abbreviata Patch	99	11	0	6
The green peach aphid	Myzus persicae (Sulz.)	127	12	0	23
The potato aphid	Macrosiphum solanifolii (Ashm.)	96	14	0	15
The foxglove aphid	Myzus pseudosolani Theob.	7	0	0	0
The pea aphid	Macrosiphum pisi (Kltb.)	0	450	334	42
Miscellaneous		0	38	0	8

¹ Young clover in fields from which peas were harvested.

TABLE 5

Stem-End Browning and Net Necrosis as Affected by Harvest Dates

Location	Storage temp.	8/11/42	8/26/42	9/8/42	9/24/42	10/8/42	10/22/42
Per cent Stem-End Browning at different harvests							
Farm 1	36° F.	0	.93	1.44	3.02	1.44	3.73
	52° F.	7.46	9.80	9.84	11.96	18.73	15.13
Per cent Net Necrosis at different harvests							
Farm 1	36° F.	0	.93	1.76	1.90	1.76	5.42
	52° F.	2.69	9.24	11.58	6.66	11.88	8.52
Per cent Stem-End Browning at different harvests							
Farm 2	36° F.	1.76	1.13	1.68	4.09	3.38	6.45
	52° F.	6.41	18.46	23.00	14.89	13.33	18.23
Per cent Net Necrosis at different harvests							
Farm 2	36° F.	2.35	11.32	11.40	26.36	31.71	33.54
	52° F.	20.26	37.69	39.80	48.08	55.69	45.68

TABLE 6

Mean Stem-End Browning and Net Necrosis Percentages in Samples from Four Fields in Seven Bins¹

Bin	1	2	3	4	5	5	6	12
Temperature °F.	33	37	40	44	47	47	51	60
Series	A	A	A	B	A	B	B	B
Mean Net Necrosis Per Cent								
Field I	12	17	24	29	33	32	32	26
Field II	0.1	0.1	0.4	0.2	0.5	0.2	0.5	0.5
Field III	10	17	25	20	28 ²	20 ²	21	19
Field IV	13	15	23	32	31	34	37	33
Mean Stem-End Browning Per Cent ³								
Field I	6	5	6	7	8	7	9	13
Field II	10	11	15	18	29	26	33	47
Field III	3	3	2	2	3	3	8	9
Field IV	3	3	4	5	5	4	8	9

¹ Each mean represents 4 to 6 samples, usually 6.² In III, series A was dug from part of the field closer to a Katahdin field than series B. Possibly more leafroll came into A than into B from the Katahdin field.³ In fields I, III, and IV, masked in part by net necrosis, according to Goven.

TABLE 7

Relationship of Maximum Net Necrosis Per cent to Leafroll Per cent Spread in 1941

Field Series	Leafroll per cent				Net necrosis per cent (and number of samples)		Leafroll per cent 1941-42 showing as net necrosis ³		Leafroll per cent 1941 spread showing as net necrosis ⁴	
	1941 from seed ¹	1941-42 ²		1941 spread			Bin 5	Bin 6	Bin 5	Bin 6
		Green-house	Florida							
I A } B }	5	42		37	{ 41(3) 40(3)		98 95	95	111 108	108
II A } B }	0.1		0.8	0.7	{ 0.6(5) 0.6(2)	40(3)	75 75	75	88 88	88
III A } B }	7	36		29	{ 28(6) 21(5)	24(2)	78 58	67	97 72	86
IV A } B }	7	48		41	{ 31(6) 32(5)	37(6)	65 67	77	76 78	90

¹ Estimates by Upton from memory 4/15/42.² One sample from each field; this sample is used here for comparison in each series.³ Average I 96

II 75

III 68

IV 79

⁴ Average I 100 (probably greenhouse sample was too small to give representative reading.)

II 88

III 84

IV 81

TABLE 8

Net Necrosis and Stem-End Browning on Organic Plots—1941

Previous crop and treatment ¹		Pounds per acre 8-16-20 on potatoes	Net necrosis Per cent	Stem-End Browning Per cent
Potatoes	1,000	1,000	10.7	7.6
Potatoes	1,500	1,500	24.7	9.4
Crimson	0	1,000	20.6	6.2
Corn	0	1,000	8.8	3.2
Crimson	0	1,500	17.6	13.9
Corn	0	1,500	19.1	5.2
Crimson	250	750	11.6	4.1
Corn	250	750	2.8	4.7
Crimson	500	1,000	9.9	6.5
Corn	500	1,000	15.3	4.0
Average of all crimson plots			14.8	7.1
Average of all corn plots			11.6	4.4

¹ Figure indicates pounds per acre of fertilizer used.

TABLE 9

*Stem-End Browning and Net Necrosis in Potatoes from the
Permanent Plots—1941*

Treatment	Average	
	% N.N.	% S.E.B.
Check Plots		
2,000 lbs. of 4-8-8 (N. half)	8.0	12.0
2,000 lbs. of 4-8-8	9.7	21.4
Rate of Application		
No fertilizer	1.6	1.6
1,500 lbs.	4.5	9.6
2,000 lbs.	9.7	21.4
2,500 lbs. (on Knoll)	13.6	24.8
3,000 lbs.	17.7	29.8
Fertilizer Ratios		
0-8-8	5.8	12.7
2-8-8	6.7	12.9
4-8-8	9.7	21.4
6-8-8	11.7	13.0
4-0-8	13.5	12.3
4-4-8	6.5	11.7
4-8-8	9.7	21.4
4-12-8	10.9	16.5
4-8-0	.8	.5
4-8-4	6.2	3.6
4-8-8	9.7	21.4
4-8-10	8.0	20.9
4-8-12	11.6	48.2
Sources of Nitrogen		
Nitrate of soda	6.8	15.7
Sulfate of ammonia	12.0	14.6
Urea	7.9	12.1
Fish meal	12.6	14.5
Cyanamid	9.8	12.6
½-½-0	11.0	13.2
¾-¾-¼	9.7	21.4
¼-¼-½	7.6	12.8
Chemically Pure Salts		
Plot 1	1.6	1.8
" 2	4.1	2.7
" 3	2.8	3.6
" 4	3.5	3.4
" 5	5.2	2.6
" 6 (on Knoll)	2.3	1.1
" 7	3.7	2.5
Acid versus Neutral Fertilizers		
Acid mixture	7.1	12.3
Acid mixture plus kieserite	11.0	10.3
Acid mixture plus dolomite	8.9	15.1
Acid mixture plus calcium limestone	8.2	11.4
Potassium Sulfate versus Potassium Chloride		
K ₂ SO ₄ Unlimed N. ½ plot	2.6	4.7
K ₂ SO ₄ Limed ½ plot	4.6	4.8
KCl Unlimed N. ½ plot	8.0	12.0
KCl Limed ½ plot	8.1	23.6
Check Plots		
2,000 lbs. of 4-8-8	12.0	14.9
2,000 lbs. of 4-8-8	19.2	19.0

TABLE 9—(Continued)

Treatment	Average	
	% N.N.	% S.E.B.
Effect of Organic Matter		
Check, crimson removed	9.3	13.7
Check	19.2	19.0
Check, plus crimson from plot 427	17.7	15.3
Check, plus straw (6 tons per acre)	11.4	19.4
Check, plus manure (20 tons per acre)	14.8	24.3
Sources of Nitrogen		
Nitrate of soda	12.2	15.6
Sulfate of ammonia		
(unlimed N. $\frac{1}{2}$ of plot)	13.3	7.3
(limed $\frac{1}{2}$ of plot)	11.3	17.4
Ammonium chloride		
(unlimed N. $\frac{1}{2}$ of plot)	25.7	20.2
(limed $\frac{1}{2}$ of plot)	29.7	31.3
$\frac{1}{2}$ nitrate of soda, $\frac{1}{2}$ sulfate of ammonia	7.3	17.3
Delayed nitrogen	6.4	14.0
Broadcast Application of P_2O_5 and K_2O		
A—4-8-8 ($\frac{1}{2}$ - $\frac{1}{2}$ -0) 2,000 lbs. per acre	4.4	9.0
B—4-8-8 plus Ca hydrate	11.9	18.5
C—4-8-8 plus MgO 2,000 lbs. Sea Water MgO	11.7	14.5
D—4-8-8 Dol. L.S. 2,000 lbs. per acre	3.2	7.6
(D = D.L.S. containing 670 lbs. CaO (B received), and 380 lbs. MgO (C received).)		
Continuous Cropping to Potatoes		
Check, plus peat (1936-1940 total 40 tons)	3.9	8.5
Check	4.1	21.4
4-8-10	4.1	25.3
2,500 lbs. of 4-8-8	7.9	20.6
Check plus 20 tons manure	27.6	23.1
Total of all plots	8.60	12.83

TABLE 10

*Net Necrosis and Stem-End Browning on Potash Source
and Ratio Test—1941*

Treatment	Farm A		Farm B	
	% N.N.	% S.E.B.	% N.N.	% S.E.B.
4-8-8 KCl	1.9	42.0	18.1	11.1
4-8-10 KCl	1.1	38.5	20.5	6.9
4-8-12 KCl	.7	33.2	19.1	6.9
4-8-16 KCl	2.2	31.8	26.2	7.2
4-8-8 K_2SO_4	3.1	19.3	14.8	5.3
4-8-10 K_2SO_4	1.0	30.5	16.5	5.1
4-8-12 K_2SO_4	1.5	28.9	8.2	6.9
4-8-16 K_2SO_4	.5	14.4	12.1	4.8
4-8-8 $\frac{1}{2}$ from each salt	2.8	6.4	12.2	7.1
4-8-10 $\frac{1}{2}$ from each salt	1.3	11.7	19.0	3.6
4-8-12 $\frac{1}{2}$ from each salt	0	26.5	18.6	6.3
4-8-16 $\frac{1}{2}$ from each salt	.9	43.9	19.1	11.3
4-8-10 $\frac{1}{2}$ KCl, $\frac{1}{2}$ K_2SO_4	1.4	13.7	18.9	7.7
4-8-10 $\frac{1}{2}$ KCl, $\frac{1}{2}$ KNO_3	.4	42.2	14.5	9.8
4-8-10 $\frac{1}{2}$ K_2SO_4 , $\frac{1}{2}$ KNO_3	1.8	26.8	5.3	8.1
Average for farm	1.4	26.8	16.0	7.3

TABLE 11

Net Necrosis Percentages in Samples from Field IV

Days after digging	Net necrosis percentages in different samples ¹							
	1 33° A	2 37° A	3 40° A	4 44° B	5 47° A	5 47° B	6 51° B	12 60° B
3 ²	10	10	10	10	10	10	10	10
43	13	15	21	27	34	—	—	—
44	—	—	—	—	—	31	38	36
52	13	—	—	—	—	—	—	—
53	—	15	20	31	30	35 ⁴	—	—
57	—	—	—	—	—	—	37	35
70	12	—	—	—	—	—	—	—
71	—	13	22	—	30	—	—	—
72	—	—	—	35	—	32	—	—
74	—	—	—	—	—	—	37	32
100	12	—	—	—	—	—	—	—
101	—	14	23	—	—	—	—	—
102	—	—	—	34	30	33	—	—
105	—	—	—	—	—	—	35	34
127	12	—	—	—	—	—	—	—
128	—	15	25	—	—	—	—	—
129	—	—	—	33	31	—	—	—
130	—	—	—	—	—	35	—	—
133	—	—	—	—	—	—	37	—
134	—	—	—	—	—	—	—	30
154	15	—	—	—	—	—	—	—
155	—	15 ³	24	32	29	35	36	—
156	—	—	—	—	—	—	—	30
Total	77	87	135	192	184	201	220	197
Mean	13	15	23	32	31	34	37	33

¹ The next 3 lines indicate respectively the bins (1 to 6 and 12), the mean temperatures in °F., and the series.

² Samples examined at beginning of storage period. Excluded from total below.

³ Maximum (15.4%) for bin 2.

⁴ Maximum (35.2%) for bin 5, series B.

TABLE 12

Net Necrosis Percentages in Samples from Field I

Days after digging	Net necrosis percentages in different samples ¹							
	1 33° A	2 37° A	3 40° A	4 44° B	5 47° A	5 47° B	6 51° B	12 60° B
2 ²	7	7	7	—	7	—	—	—
5 ²	—	—	—	6	—	6	6	6
19	—	—	—	—	—	—	15	—
21	5	5	12	—	—	—	—	—
22	—	—	—	18	16	16	—	16
30	7	10	—	—	—	—	—	—
31	—	—	13	22	29	—	—	—
32	—	—	—	—	—	28	24	—
33	—	—	—	—	—	—	—	27
43	10	—	—	—	—	—	—	—
45	—	12	—	—	—	—	—	—
46	—	—	19	28	29	27	—	—
51	—	—	—	—	—	—	32	30
63	—	25	—	—	—	—	—	—
64	14	—	—	—	—	—	—	—
65	—	—	30	33	40	41	—	—
66	—	—	—	—	—	—	39	31
91	17	—	—	—	—	—	—	—
92	—	24	33	—	42	—	—	—
93	—	—	—	35	—	40	—	—
96	—	—	—	—	—	—	40	—
120	18	—	—	—	—	—	—	—
121	—	26	—	—	—	—	—	—
122	—	—	34	36	41	—	—	—
126	—	—	—	—	—	40	—	—
127	—	—	—	—	—	—	41	—
Total	71	102	141	172	197	192	191	104
Mean	12	17	24	29	33	32	32	26

¹ The next 3 lines indicate respectively the bins (1 to 6 and 12), the mean temperatures in °F., and the series.

² Samples examined at beginning of storage period. Excluded from total below.

TABLE 13

*Net Necrosis and Stem-End Browning Percentages in Samples from Field II,
Mostly Shifted from Low to Moderately High Temperature During Storage*

Series	Sample	1st period		2nd period		Both periods		N.N. %	S.E.B. %	Conclusions
		Temp. °F.	Days	Temp. °F.	Days	Mean temp. °F.	Days			
A	205	34	63	—	—	34	63	0	11	30 days at 34° reduced S.E.B. development at 50° later
A	214	34	30	50	34	43	64	0.5	14	
A	212	34	20	51	44	46	64	0.3	28	
A	210	34	10	51	54	48	64	0.2	26	
A	206	33	90	—	—	33	90	0.4	12	
A	215	35	30	52	61	46	91	0.7	21	
A	213	34	20	52	71	48	91	0.5	28	
A	207	33	120	—	—	33	120	0.2	13	90 days at 34° inhibited S.E.B. development at 52° later, and 60 days at 34° greatly reduced it
A	218	34	90	52	31	39	121	0	13	
A	217	34	60	52	60	43	120	0.2	14	
A	216	34	30	52	90	48	120	0.4	23	
A	218	34	90	52	31	39	121	0	13	31-35 days at 50-52° induced more S.E.B. after 10 days at 34° than after 30-90 days at 34°
A	214	34	30	50	34	43	64	0.5	14	
A	209	34	10	50	35	46	45	0.6	17	
A	217	34	60	52	60	43	120	0.2	14	45-61 days at 46-52° induced less S.E.B. as previous storage at 34-35° was longer
A	215	35	30	52	61	46	91	0.7	21	
A	210	34	10	51	54	48	64	0.2	26	
B	246	—	—	46	45	46	45	0	30	

TABLE 14

*Net Necrosis and Stem-End Browning Percentages in Samples from Field III,
Mostly Shifted from Low to Moderately High Temperature During Storage*

Series	Sample	1st period		2nd period		Both periods		N.N. %	S.E.B. %	Conclusions
		Temp. °F.	Days	Temp. °F.	Days	Mean temp. °F.	Days			
A	313	35	50	47	20	38	70	12	2	After 50 days at 35°, the longer the storage at 47° the more N.N. % developed
A	314	35	50	47	22	39	72	14	2	
A	315	35	50	47	30	40	80	16	3	
A	316	35	50	48	41	41	91	19	2	
A	317	35	50	47	50	41	100	21	4	
A	333	—	—	47	73	47	73	27	3	
A	305	33	100	—	—	33	100	11	4	The higher the mean temp. during 100 days storage, the more N.N. % developed
A	318	34	75	47	25	37	100	16	3	
A	317	35	50	47	50	41	100	21	4	
A	334	—	—	47	101	47	101	26	5	
A	308	34	25	46	17	39	42	19	1	17-25 days at 46-47° induced less N.N. % after 50-75 days at 34-35° than after 25 days at 34°
A	309	34	25	46	24	40	49	21	3	
A	313	35	50	47	20	38	70	12	2	
A	314	35	50	47	22	39	72	14	2	
A	318	34	75	47	25	37	100	16	3	
A	305	33	100	—	—	33	100	11	4	

TABLE 15

*Net Necrosis and Stem-End Browning Percentages in Samples from Field I,
Mostly Shifted from Moderately High to Low Temperature During Storage*

Series	Sample	1st period		2nd period		Both periods		N.N. %	S.E.B. %	Conclusions
		Temp. °F.	Days	Temp. °F.	Days	Mean temp. °F.	Days			
B	146	47	46	—	—	47	46	27	9	Net necrosis percentage is increased by higher mean temperature
A	133	47	46	—	—	47	46	29	9	
B	153	47	20	35	31	40	51	27	6	
B	151	47	10	35	41	37	51	20	7	
A	104	—	—	35	43	35	43	10	6	
B	147	47	65	—	—	47	65	41	6	Do
A	134	47	65	—	—	47	65	40	6	
B	156	47	30	35	36	40	66	30	7	
B	154	47	20	34	46	38	66	31	4	
B	152	47	10	34	55	36	65	21	4	
A	105	—	—	34	64	34	64	14	7	
B	148	47	93	—	—	47	93	40	7	Do
A	135	47	92	—	—	47	92	42	8	
B	157	47	30	34	65	38	95	34	8	
B	155	47	20	34	75	37	95	31	5	
A	106	—	—	33	91	33	91	17	6	
B	149	47	126	—	—	47	126	40	8	Do
A	136	47	122	—	—	47	122	41	10	
B	160	47	90	32	37	43	127	39	10	
B	159	46	60	33	66	39	126	35	10	
B	158	47	30	33	96	36	126	34	7	
A	107	—	—	33	120	33	120	18	6	

TABLE 16

*Net Necrosis and Stem-End Browning Percentages in Samples from Field II,
Mostly Shifted from Moderately High to Low Temperature During Storage*

Series	Sample	1st period		2nd period		Both periods		N.N. %	S.E.B. %	Conclusions
		Temp. °F.	Days	Temp. °F.	Days	Mean temp. °F.	Days			
B	246	46	45	—	—	46	45	0	30	Stem end browning percentage is increased by higher mean temperature
B	253	47	20	38	28	42	48	0	14	
B	251	47	10	38	38	40	48	0.2	15	
A	204	—	—	35	45	35	45	0	9	
B	247	47	66	0	0	47	66	0	30	Do
B	256	47	30	38	36	42	66	0.2	17	
B	254	47	20	38	46	41	66	0.3	14	
B	252	47	10	38	56	39	66	0.2	14	
A	205	—	—	34	63	34	63	0	11	Do
B	248	47	94	—	—	47	94	0.9	33	
B	257	47	30	37	65	40	95	0.3	17	
B	255	47	20	37	74	39	94	0	13	
A	206	—	—	33	90	33	90	0.4	12	Do
B	249	47	122	—	—	47	122	0.3	33	
B	260	47	90	36	33	44	123	0.5	30	
B	259	47	60	36	63	41	123	0.2	29	
B	258	47	30	36	93	39	123	0.5	19	
A	207	—	—	33	120	33	120	0.2	13	

TABLE 17

Percentage of Net Necrosis, Stem-End Browning, and Total Tubers with 10 Per cent Waste Due to Net Necrosis and Stem-End Browning, by Number and by Weight

Sample	Tubers by number					Tubers by weight				
	Total No.	Net Necrosis		Stem-End Browning		Total Lbs.	Net Necrosis		Stem-End Browning	
		Total %	Cull ¹ %	Total %	Cull ¹ %		Total %	Cull ¹ %	Total %	Cull ¹ %
465 (Bin 6)	620	37.3	37.3 (all of the NN)	9.8	3.9 (26.4% of the SEB)					
471 (Bin 12)	580	30.0	29.1 (97.1% of the NN)	10.5	4.7 (44.3% of the SEB)	140	35.5	34.1 (96.0% of the NN)	9.9	4.6 (47.1% of the SEB)
371 (Bin 12)	380	19.7	19.7 (all of the NN)	13.2	4.5 (34.0% of the SEB)					
PP403 ² (Bin 11, 40-42°)	180	8.9		16.7		49.5	10.6		19.2	5.1 (26.3% of the SEB)

¹ Cull means tubers each of which lost 10 per cent or more by weight when all internally discolored tissue was removed.

² Permanent Plot sample.

TABLE 18

Effect of B, Cu, Fu, and Zn in Fertilizer on Stem-End Browning and Net Necrosis—1941

Treatment	Stem-End Browning			Net Necrosis		
	Unlimed	Limed ¹	Average	Unlimed	Limed ¹	Average
Regular 8-16-16	18.0	15.2	16.6	15.9	19.0	17.4
Regular + 10# Borax	10.8	11.2	11.0	14.8	14.5	14.6
Regular + 10# CuCl ₂	17.2	23.5	20.4	10.5	11.1	10.8
Regular + 50# CuCl ₂	11.9	14.8	13.4	11.3	11.7	11.5
Regular + 100# CuCl ₂ ²	13.3	10.1	11.7	10.7	7.7	9.2
Regular 50# CaF ₂	18.2	20.5	19.4	14.0	11.9	13.0
Regular 25# ZnSO ₄	10.6	18.1	14.4	23.1	19.6	21.4
4-8-4 50# CuSO ₄	6.6	10.7	8.6	12.8	15.3	14.0
4-8-16 50# CuSO ₄	10.1	14.8	12.4	10.1	12.0	11.0

¹ Limed at rate of 1,000 pounds hydrated dolomite per acre.

² Planted 6 days later on June 18, 1941.

TABLE 20

*Net Necrosis and Stem-End Browning Percentages in Samples from Field I,
Mostly Shifted from Low to Moderately High Temperature During Storage*

Series	Sample	1st period		2nd period		Both periods		N.N. %	S.E.B. %	Conclusions
		Temp. °F.	Days	Temp. °F.	Days	Mean temp. °F.	Days			
A	103	34	30	—	—	34	30	7	6	10 days at 34° reduced net necrosis development at 47° later
A	108	34	10	47	20	43	30	13	6	
A	132	—	—	47	31	47	31	29	7	
B	145	—	—	47	32	47	32	28	7	
A	104	35	43	—	—	35	43	10	6	
A	111	34	20	46	24	41	44	13	9	
A	109	34	10	46	34	43	44	20	12	
A	133	—	—	47	46	47	46	29	9	
B	146	—	—	47	46	47	46	27	9	
A	105	34	64	—	—	34	64	14	7	
A	114	34	30	47	34	41	64	15	6	20 to 30 days at 34° reduced net necrosis development at 47° later
A	112	34	20	47	44	43	64	19	7	
A	110	34	10	47	54	45	64	37	5	
B	147	—	—	47	65	47	65	41	6	
A	106	33	91	—	—	33	91	17	6	20 days at 34° reduced net necrosis development at 47° later while 30 days inhibited it
A	115	34	30	47	61	43	91	16	8	
A	113	34	20	47	71	44	91	23	6	
A	135	—	—	47	92	47	92	42	8	
B	148	—	—	47	93	47	93	40	7	30 to 90 days at 34° inhibited net necrosis development at 47° later
A	107	33	120	—	—	33	120	18	6	
A	118	34	90	47	31	38	121	13	7	
A	117	34	60	47	60	41	120	15	9	
A	116	34	30	47	90	44	120	18	7	
B	149	—	—	47	126	47	126	40	8	
A	118	34	90	47	31	38	121	13	7	31 to 34 days at 46-47° induced less net necrosis percentage according to preceding length of storage at 34°
A	114	34	30	47	34	41	64	15	6	
A	109	34	10	46	34	43	44	20	12	
A	132	—	—	47	31	47	31	29	7	
A	112	34	20	47	44	43	64	19	7	44-46 days at 47° induced less net necrosis after 20 days at 34°
A	133	—	—	47	46	47	46	29	9	
A	117	34	60	47	60	41	120	15	9	54-65 days at 47° induced much less net necrosis after 30-60 days at 34° than after 0-10 days
A	115	34	30	47	61	43	91	16	8	
A	110	34	10	47	54	45	64	37	5	
B	147	—	—	47	65	47	65	41	6	
A	116	34	30	47	90	44	120	18	7	90-92 days at 47° induced much less net necrosis after 30 days at 34° than after none at 34°
A	135	—	—	47	92	47	92	42	8	
B	148	—	—	47	93	47	93	40	7	

TABLE 21

Stem-End Browning Percentages in Samples from Field II

Days after digging	Stem-End Browning Percentages in different samples ¹							
	1 33° A	2 37° A	3 40° A	4 44° B	5 47° A	5 47° B	6 51° B	12 60° B
6 ²	4	4	4	—	4	—	—	—
7 ²	—	—	—	5	—	5	5	5
17	7	10	—	—	—	—	—	—
18	—	—	10	—	—	—	—	—
20	—	—	—	12	10	—	—	—
21	—	—	—	—	—	10	10	28
27	6	—	—	—	—	—	—	—
29	—	12	14	—	—	—	—	—
30	—	—	—	14	—	22	—	—
32	—	—	—	—	27	—	—	—
34	—	—	—	—	—	—	33	50
45	9	9	11	16	29	30	—	—
48	—	—	—	—	—	—	33	—
49	—	—	—	—	—	—	—	53
63	11	—	—	—	—	—	—	—
64	—	11	—	—	—	—	—	—
65	—	—	13	20	33	—	—	—
66	—	—	—	—	—	30	39	48
90	12	—	—	—	—	—	—	—
91	—	12	—	—	—	—	—	—
92	—	—	14	—	37	—	—	—
94	—	—	—	22	—	33	—	—
95	—	—	—	—	—	—	43	—
97	—	—	—	—	—	—	—	48
120	13	—	—	—	—	—	—	—
121	—	13	25	—	—	—	—	—
122	—	—	—	22 ³	39	33 ⁴	—	—
125	—	—	—	—	—	—	42	52
Total	58	67	87	196	175	158	200	279
Mean	10	11	15	18	29	26	33	47

¹ The next 3 lines indicate respectively the bins (1 to 6 and 12), the mean temperatures in °F., and the series.

² Samples examined at beginning of storage period. Excluded from total below.

³ Maximum (22.3%) for bin 4.

⁴ Maximum (33.1%) for bin 5, series B.

TABLE 22

Yield for Houma Potato Plots Sprayed with Different Copper Spray Fungicides in 1941 with a Horse-Drawn, Wheel-Traction Outfit

Fungicide	Formula	Yield per acre ¹	
		Bushels	Barrels
Tribasic copper sulphate ²	4 - 100	350± 8.7	127±3.2
Copper hydro arsenate ³	5 - 100 and 0.5 pound soybean flour	365± 8.3	133±2.9
Copper hydro arsenate-lite ⁴	Do	364±10.0	132±3.7
Spray-cop ⁵	6 - 100	348± 8.7	127±3.1
General Chemical Company fungicide ⁶	4 - 100	351± 6.2	128±2.1
Yellow cuproicide ⁷	1 - 100	330±11.4	120±4.1
Bordeaux mixture control	10-5-100	353± 6.7	128±2.5

¹ Each yield rate is a mean from eight replicated plots each containing 240 feet of row. Significantly different from bordeaux rate in no case, but nearly so for yellow cuproicide.

² Said to contain 53 per cent metallic copper; manufactured by Tennessee Copper Co., Copperhill, Tenn.

³ Said to contain approximately 17.97 per cent metallic copper and 10.59 per cent arsenic; manufactured by Chipman Chemical Co., Bound Brook, N. J.

⁴ Said to contain approximately 18.18 per cent metallic copper and 10.71 per cent arsenic; manufactured by Chipman Chemical Co., Bound Brook, N. J.

⁵ Said to contain 34 per cent metallic copper; manufactured by General Chemical Co., New York, N. Y.

⁶ Said to contain 34 per cent metallic copper plus a sticking agent; manufactured by General Chemical Co., New York, N. Y.

⁷ Said to contain 83 per cent metallic copper; manufactured by Röhm and Haas Co., Philadelphia, Pa.

TABLE 23

Yield Comparison of Green Mountain Plots Sprayed with Bordeaux Prepared with Different Formulae

Formula	Yield rate per acre ¹		Approximate odds in comparison with 10-5-100 formulae
	Barrels	Bushels	
10-10-100	160±2.8	440± 8.1	1.00 to 1
8-8-100	153±3.5	421± 9.8	1.00 to 1
8-4-100	162±3.9	445±10.9	1.39 to 1
10-5-100	156±3.2	428± 8.8	—
Check not sprayed	99±0.2	271± 0.5	Very high

¹ Each yield rate is a mean from eight replicated two-row plots each consisting of 270 feet of row.

TABLE 24

The Effect on Yield of Spraying Green Mountain Potatoes with Copper Fungicides and with Combinations of These Fungicides with Rotenone for 1941¹

Fungicide	Formula	Yield per acre 1941 barrels ² ³		Increase from applying rotenone	
		Without rotenone	With rotenone	Barrels	%
Bordeaux mixture	10-10-100	169	181	12	7.1
Bordeaux mixture	10- 5-100	169	178	9	5.3
Basi-cop ⁴	5-100	168	177	9	5.1
Spray-cop ⁵	6-100	162	179	17	9.5
Yellow cuprocide ⁶	1.5-100	167	178	11	6.6

¹ Data for a similar experiment in 1940 are presented in Bul. 465, page 483.

² Significance at 5 per cent level is 7.36 barrels.

³ Each yield rate is a mean from 14 replicated plots, each plot consisting of 1,200 feet of row.

⁴ Said to contain 52 per cent metallic copper; manufactured by Sherwin-Williams Co., Cleveland, O.

⁵ Said to contain 84 per cent metallic copper; manufactured by General Chemical Co., New York, N. Y.

⁶ Said to contain 83 per cent metallic copper; manufactured by Röhm and Haas Co., Philadelphia, Pa.

TABLE 25

Yields for Green Mountain Plots Receiving Dust or Bordeaux Fungicide with and without an Insecticide

Fungicide	Yield per acre ¹	Yield increase per acre in comparison with bordeaux ²
	Barrels	Barrels
Dust and oil ³	168±1.21	9
Dust, oil, and insecticide ³	175±1.96	16
Bordeaux (10-5-100) ⁴	159±1.8	—
Bordeaux and rotenone ⁴	173±1.3	14

¹ Each yield rate is from 10 replicated plots each containing 300 feet of row.

² Significance at the 5 per cent level is 5.43 barrels.

³ The Vapo Dust machine is manufactured by the Root Duster Co. of Cleveland, O., and was supplied by courtesy of the California Spray Chemical Company, Elizabeth, N. J. Approximately 40 pounds of dust was applied per acre per application. The dust consisted of 6 per cent Red Copper Oxide and 94 per cent Bancroft Clay. Approximately 2 gallons of "Vaporal" mineral oil was applied per acre per application. The insecticide in the form of "Extrax" contained 2.5 per cent rotenone and 0.4 per cent pyrethrum and was added to the oil at the rate of one pint to two gallons of oil.

⁴ Bordeaux was applied with a tractor power spray machine. Three pounds of four per cent rotenone in the form of ground derris root was mixed with 100 gallons of bordeaux just prior to making the application.

TABLE 26

Effect of Seed Spacing on Yield of Eight Potato Varieties—1941

Stillwater, Maine					Presque Isle, Maine						
Variety	Total yield		Per cent U.S. No. 1	U.S. No. 1		Variety	Total yield		Per cent U.S. No. 1	U.S. No. 1	
	Bu.	Bbl.		Bu.	Bbl.		Bu.	Bbl.		Bu.	Bbl.
Six-inch spacing											
Earlaine #2	447	163	89	397	144	Earlaine #2	504	183	82	416	151
Chippewa	398	145	85	341	124	Warba	434	158	79	344	125
Houma	391	142	81	315	115	Katahdin	432	157	88	380	138
Sebago	369	134	84	309	112	Sebago	417	152	—	—	—
Katahdin	357	130	86	307	112	Houma	406	148	73	295	107
Green Mountain	338	123	89	301	109	Chippewa	400	145	76	302	110
Irish Cobbler	288	105	78	224	81	Green Mountain	393	143	90	334	121
Warba	279	101	85	238	87	Irish Cobbler	371	135	60	249	91
Nine-inch spacing											
Earlaine #2	446	162	91	406	148	Earlaine #2	502	183	87	439	160
Chippewa	365	133	87	317	115	Sebago	419	152	82	346	126
Sebago	360	131	91	325	118	Chippewa	408	148	80	327	119
Katahdin	337	123	91	305	111	Katahdin	400	145	87	348	127
Houma	324	118	82	267	97	Irish Cobbler	394	143	76	301	109
Green Mountain	322	117	92	297	108	Houma	387	141	77	296	108
Irish Cobbler	305	111	84	257	93	Green Mountain	384	140	89	342	124
Warba	253	92	85	215	78	Warba	360	131	84	302	110
Twelve-inch spacing											
Earlaine #2	410	149	93	381	139	Earlaine #2	510	185	92	470	171
Sebago	336	122	92	311	113	Katahdin	397	144	89	352	128
Chippewa	329	120	91	298	108	Sebago	393	143	82	322	117
Katahdin	317	115	92	293	107	Warba	388	141	86	331	120
Houma	317	115	82	261	95	Chippewa	375	136	86	323	117
Green Mountain	289	105	93	269	98	Irish Cobbler	374	136	81	302	110
Irish Cobbler	272	99	89	241	88	Green Mountain	370	135	90	334	121
Warba	260	95	88	229	83	Houma	360	131	81	291	106

TABLE 27

1941 Yield Test—Starch Varieties Randomized with Five Replicates A to E

Variety	No. of potatoes to 5 kg.	Flesh color	Starch Ave. of 5 plots	Starch per acre basis primes and culls	Starch per 11 pk. bbl. ¹
				Lbs.	Lbs.
Parnasia	45	W	16.0	1,080	26.5
Matador	31	Y-W	17.3	2,760	28.7
Popular	71	Y	18.6	2,450	30.8
Record	42	Y	18.9	3,790	31.1
Fruhgold	49	Y	14.1	2,830	23.4
Ostbote	49	Y-W	20.4	4,700	33.5
Voran	45	Y-W	18.0	4,150	29.7
To be ident.	51	Y-W	18.6	4,200	30.8
Mittlefruhe	43	Y-W	17.5	3,900	28.9
Ackersegen	37	Y-W	17.0	4,460	28.1
Green Mountains	30	W	18.5	5,100	30.5
Katahdin	33	W	15.4	3,550	25.3
Houma	41	W	15.4	4,240	25.3

¹ Bushel to barrel factor 2.75.

